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AUTOMOBILE MOTORS AND MECHANISM.

A Practical Illustrated Treatise on the Power
Plant and Motive Parts of the Modern Motor
Car, for Owners, Operators, Repair-
men, and Intending Motorists.

By

THOMAS H. RUSSELL, M. E., LL. B.

Former Editor of "Modern Machinery"; Editor of
American Cyclopedia of the Automobile"; A
of "History of the [illegible]tomobile," "Auto
bile Driving [illegible]ught," "Igni[illegible]
Timing [illegible] Valve Setting,"
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Preface

In the preparation of this work the main object has been to set forth in a clear, concise manner all the essential facts regarding the motive power and parts of the modern automobile, so that the reader may, with the least possible effort, learn to regard and handle the mechanism of his car understandingly.

Beginning with the principles and construction of the improved gasolene engine, the development of which marked the birth of modern automobiling, the various machinery parts comprised in a motor car are each described in turn, their operation and functions being dealt with in non-technical language. The forms of transmission gear employed in recent models are treated at length and numerous illustrations enhance the value of the descriptive text.

Many practical hints for the proper care of the engine and motive parts will be found throughout the work. The subject of lubrication is fully covered and remedies are prescribed for many of the ills that engines are heir to, including those that may be classed under the heads of Overheating, Misfiring and Noise.

The automobile owner or operator who familiarizes himself with the contents of this work will be well equipped to satisfy the curiosity of his friends regarding automobile construction and will enjoy the confidence that is born of knowledge.

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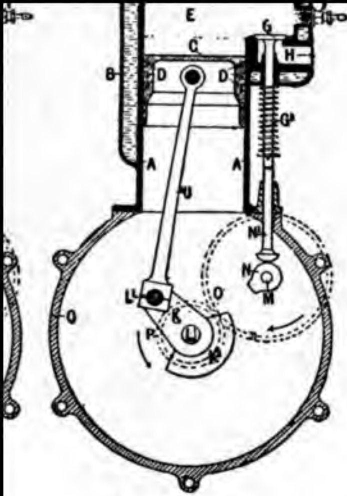
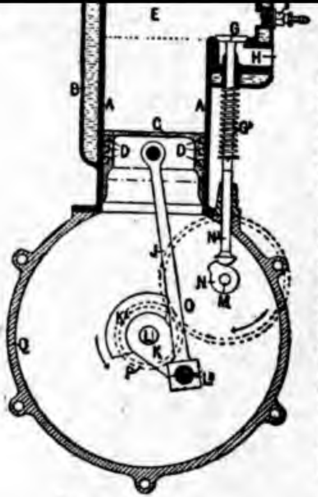


WORKING STROKE.
Firing of mixture.
J, connecting rod.
K, crank cheek.
K¹, crank balance weight.
L, crankshaft.
L¹, crank pin.
M, half-time shaft.



EXHAUST STROKE.
Exhaust valve opens.
N, exhaust valve cam.
N¹, exhaust valve tappet.
O, half-time shaft gear-wheel.
P, crankshaft gear-wheel to operate O.
Q, crank-case.

CHAPTER I.

ESSENTIAL PARTS OF A MOTOR CAR.

We may classify motor vehicles under four different types:

(1) Those propelled by means of internal combustion engines.

(2) Those propelled by steam engines.

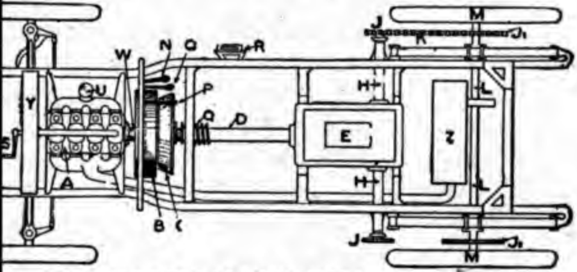
(3) Those propelled by electric motors supplied with current from a storage battery.

(4) Those propelled by electric motors, using current generated on the car by means of an internal combustion engine.

It is with the first that we shall have mostly to deal, for steam and electric cars, though successful in operation and having many firm friends and advocates, are at present in the minority.

In Figs. 1 and 2 we show how the arrangement of the various parts of the motor car is carried out.

In Fig. 1 we have a chain-driven car, and in Fig. 2 a gear-driven car. The difference between the two is small. We will take first a chain-driven car, and in most cases we have given the same reference letters to the same parts in Figs. 1 and 2. A is the engine—in this case a four-cylindered engine (it may, of course, be of one, two, three, four, six, or eight cylinders, and may be arranged differently as regards the inlet and exhaust from the method shown in our diagram). B is the flywheel of the engine and this may be regarded as the point where the power is transmitted from the engine to do the work of propelling the car. Inside B is the female ɔf a clutch, the male portion being shown at C. ch is for the purpose of connecting or disconnecting ne to or from the transmission mechanism which the power to the road wheels. D is a shaft which by the male member C of the clutch when it is in ent with the female member B. It is kept in engagement means of a spring shown diagrammatically in our ɔn. It may be arranged in a variety of ways, de- greater detail under the heading Clutch.



1.—DIAGRAMMATIC PLAN OF MOTOR CAR WITH CHAIN TRANSMISSION.

ine. N, Accelerator pedal.

may be placed at either side of the engine, and sometimes, where the inlet and exhaust valves are all on one side, it is placed on the other side on a pipe which leads through between the two pairs of cylinders to supply them with gas. W is the crank shaft, to which the flywheel B is rigidly secured.

The parts which we have described represent the power-generating plant. We will now describe that portion which is purely for transmission purposes. D is a shaft coupled to the male portion of the clutch C. This shaft is only rotated by the engine when the clutch is in engagement. It then drives through into the gear box E. In the gear box is provided a change speed gear mechanism (see Change Speed Gear), and also the differential gear and the bevel wheel, by means of which the power is transmitted from the longitudinal shaft in the gear box to the cross shafts H, H, known collectively as the countershaft, which is arranged transversely in the frame. The ends of these shafts carry sprocket wheels J, J, these sprocket wheels being connected by means of the chains K to larger sized sprocket wheels attached to the hubs of the rear wheels. These sprocket wheels are marked J1, J. L, L is a solid forged axle carrying at its ends the road wheels M, M, which revolve about it.

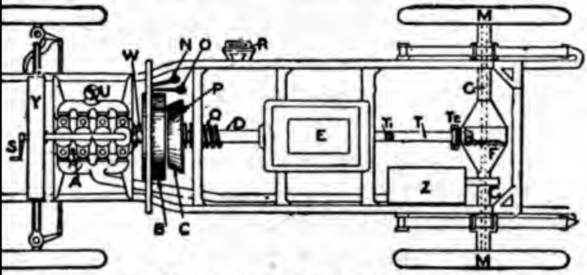
Z is the muffler, into which the exhaust gases from the engine flow.

There are three pedals shown just over the clutch. P is the clutch pedal, by depressing which the clutch is taken out of engagement. O is a pedal which operates a brake, generally on the countershaft. N is the accelerator pedal used to hold up the governor, and to thus allow the engine to attain its highest speed.

The method of arranging a motor car as we have described is one of the earliest, and is still used in a very great number of up-to-date and high-powered cars. The chain transmission, however, although it has many advantages, is often noisy, and in the more modern cars using this type of transmission chain cases have been fitted not only to deaden the t also to protect the chain from dirt and to insure r lubrication.

. 2 we show in diagrammatic form a representative ent of a car in which the transmission is by gear- ad of chains, and cars using this method are known driven cars.

as the engine, the clutch, and the shaft D go, this ent is practically the same as that in a chain- ar, but the gear box is so arranged that there is no



.–DIAGRAMMATIC PLAN OF MOTOR CAR WITH LIVE AXLE OR GEARED TRANSMISSION.

shaft must be used which will allow of movement up and down and sideways, the up and down movement being the most pronounced. This shaft is shown at T, and is known as the propeller shaft. It has a universal joint T1 at its forward end, so that the rise and fall of the back axle relatively to the frame will not affect the transmission of the power. In some cases the propeller shaft has a universal joint at either end, as in our illustration, and can then be described as a cardan shaft. The rise and fall, in the case of the arrangement shown as at Fig. 1, where chains are used to transmit the power, is allowed for by the chains themselves.

The power, being transmitted to the bevel wheel inside the differential case F, is transmitted from the differential gear to the road wheels by means of shafts shown in dotted lines at G. These shafts run inside the hollow axle shown, and, at their ends, are anchored to the wheels M, M.

In modern practice, these wheels M, M rotate on ball bearings outside the hollow axle, and the shafts G, which come through the inside of the axle, are at their ends attached to the wheel, and do not bear any of the weight.

So far, we have dealt purely in diagrammatic form with the two methods of transmitting the power from a gasolene engine placed in front of a car to the road wheels at the rear. The gear-driven type is the most popular. We may therefore, now describe an up-to-date gear-driven car.

The illustration, Fig. 3, shows the general arrangement of all the mechanism in a 35 H. P. Clement-Talbot car, which is taken as a type well known on both sides of the Atlantic. A is the chassis frame constructed of pressed steel of U-section. It will be seen that it is deep in the center and tapers toward each end, while the back end is curved upwards at A1, so as to clear the springs of the back axle, at the same time allowing a low platform for the body-work of the car. There is a sub-platform or frame shown by dotted lines at B, B, and this platform is constructed also of U-section stamped steel, and is supported by means of cross bearers from the main chassis

E_2, Gear changing hand lever.
E_3, Quadrant in which gear change lever works.
E_4, Hand brake lever operating rear wheel brakes.
E_5, Short end of brake lever.
E_6, Brake rod.
E_7, Brake compensating device.
E_8, One of the rods connecting the compensating device to the rear brakes.
E_9, Rocking shaft on which brake compensating device is fitted.
F, Casing of universal joint of propeller shaft.
F_1, Hexagon end of propeller shaft.
F_2, Propeller tube.
F_3, Casing of differential gear.
G, One of the radius rods.
G_1, Bracket to which radius rod G is pivoted.
H, Steering wheel.
H_1, Steering column.
H_2, Box containing worm steering gear.
H_3, Lever connecting steering gear to front wheels.
J, Solid H section front axle.
K, One of the semi-elliptic springs supporting front of chassis.
K_1, One of the rear semi-elliptic springs.
K_2, Transverse spring to which rear ends of rear springs are shackled.
K_3, V-shaped bracket supported on transverse spring.
K_4, Bracket hung from shackle joint at rear of front semi-elliptic springs.
K_5, Shackle joint at end of front springs.

frame. One of these bearers is shown at B1 in section and the other one at B2 in section, these being the forward and after cross bearers respectively. On this sub-frame are mounted the engine with its clutch and the gear box.

C is the radiator, from which a pipe is run to the pump shown at C1, this pump being gear-driven from the engine; the coupling is shown at C2. The water pipes leading from the pump of the two pairs of cylinders, and the water pipes leading from the top of the two pairs of cylinders, are clearly shown at C3. C4 is the fan situated immediately behind the radiator and driven by a belt which passes over the two pulleys C5 and C6, the latter being fixed to the shaft which drives the pump.

A starting handle is shown at C7, and the clutch by means of which it is connected to the engine shaft at C8. C9 is the aluminum box containing the contact maker and distributer, which are rotated by means of a vertical shaft C10. C11 are two vertical air release pipes (which also act as fillers for pouring the lubricating oil into the crank chamber), allowing air to escape without splashing oil up on the descent of the pistons. C12, C12, are the two exhaust outlets, the stems of the exhaust valves and their plungers being shown at C13, C13, C13, C13. Oil is led to the main bearings of the engine through the three pipes C14, C14, C14.

The general arrangement of this engine mechanism is described and illustrated in detail under the heading Internal Combustion Engine.

The engine flywheel shown at C15 incorporates inside it a clutch. D is the pedal operating the clutch through the medium of the collar D1 on the sleeve, which is operated by the clutch spring not shown. There is a ball thrust bearing at D2 which takes up the end thrust when the clutch is disengaged. The clutch pedal is also connected by means of the lever D3 to the internally expanding brake inside the drum D4 by means of the link D5 and the rocking shaft D6. Between the clutch shaft and the gear box is interposed a detachable coupling E, by means of which the clutch shaft may be detached

gear shaft, so as to allow of examination or repair
tch.

ar box is shown at E1, the gear being illustrated fully
heading Change Speed Gear. The change of speeds
r is operated by means of the hand lever E2 working
quadrant E3. The lever E4 is the brake lever, the
of which is shown at E5, and which operates the
the wheel hubs through the medium of the rod E6,
lls a compensating device E7. This device is in con-
ith the two rear brakes through the medium of two
of which is shown at E8. These rods are connected
on a rocking shaft, the center of which is shown in
ion at E9. Inside the case shown at F is a universal
from this joint the power is transmitted by means
xagon-headed propeller shaft F1 through the pro-
e F2 to the bevel drive inside the differential case
live axle. The live axle is kept at normal distance
to the chassis frame by means of radius rods, one
is shown at G, and is pivoted to a bracket G1, this
ent being duplicated on both sides of the chassis

CHAPTER II.

THE INTERNAL COMBUSTION ENGINE.

Internal Combustion Engine—This is the term which perhaps best describes the gasolene engine or motor with which most automobilists have to do. The principle of operation is based on the well-known facts that gasolene vapor or a fine spray of gasolene mixed with air forms a highly inflammable mixture, and that if this mixture be confined in a closed chamber and ignited by a flame or spark it will explode and expand. This is just what is done in a gasolene engine, the expansion being utilized as the motive power.

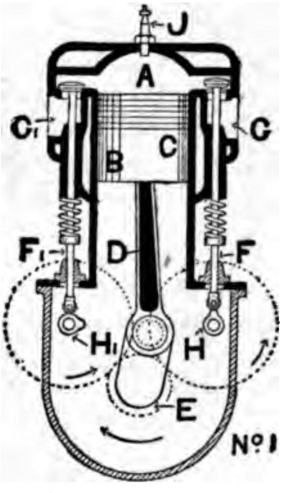
An internal combustion engine can use various kinds of fuel, but all of them are hydrocarbons. Heavy oils are not much used in motor car practice except on heavy vehicles; and, for the sake of description, we shall take it that the internal combustion engine used in the automobile will burn the very light hydrocarbon known as gasolene or petroleum spirit. It is from this that the gas is produced which is burned inside the engine.

The production of the gas from the hydrocarbon is the function of the carbureter. (See Carbureter.) The gas, being

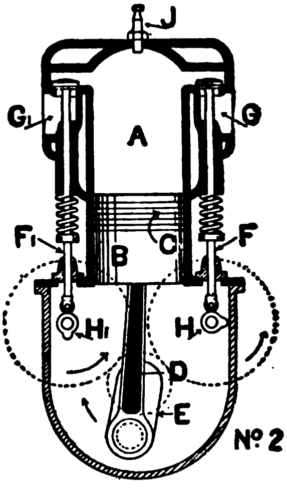
ive or explosive when ignited, is used to force a piston
linder outward, this piston being connected by means
nnecting rod to the crank in such a manner that when
rced out by the expansion of the gas in the cylinder it
he crank; but the mechanism which is required to pro-
his apparently simple operation has other functions to
n. Before the gas can be exploded in the cylinder, it
ssary to draw it in, which means that there must be
pening in the cylinder through which it may pass. Be-
can be exploded so that it will drive the piston down in
inder, there must be some means of closing up the
e through which it has passed into the cylinder; while,
before the operation of exploding the gas can be re-
it is essential to get rid of the exhaust gases gener-
the explosion. Also, some method of igniting the
as to cause it to expand must be provided. This latter
ment is usually attained by means of an electric spark.
h r fact to be noted is that the explosive gas drawn
cylinder will give out greater power when ignited if
st compressed, and therefore the engine has also to

but it is provided with spring rings, which prevent any gas passing by it. D is the connecting rod which connects the piston to the crank E, which crank forms part of the engine shaft, and it is by the rotation of this that the car is driven. The piston B, when it is forced down in the cylinder, pushes round the crank E, and so turns the shaft. F and F1 are, respectively, the inlet and exhaust valves.

The gas from the carbureter enters at G, and, after having been ignited, is expelled through the port G1. The valves F and F1 are operated by the engine itself by means of cams H and H1. These cams are carried on shafts which are driven by the engine crank shaft, but at half its speed. The dotted lines indicate the gear wheels on the two shafts and on the engine, by means of which the shafts are rotated. It will be seen that the cam on either of these shafts will lift its valve once in every two revolutions of the crank shaft.

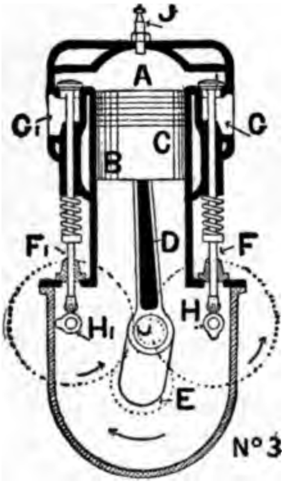


SUCTION STROKE

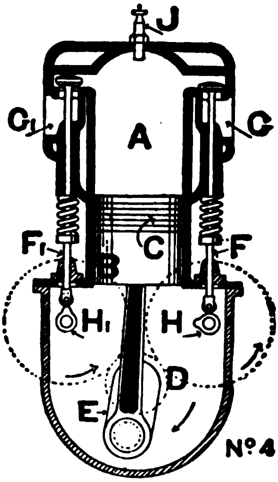


COMPRESSION STROKE

In Fig. 1 we see that the cam has lifted the inlet valve F. At the same time the crank is in such a position that the piston is just descending in the cylinder. As the piston descends it acts as a suction pump, and draws in the gas from the carbureter through the valve port G. As soon as the piston has reached the bottom of its stroke the cam H allows the valve F to fall on its seat. The flywheel on the crank shaft of the engine, however, through its stored momentum, continues to rotate the crank, and therefore the piston B is pushed back again into the cylinder (Fig. 2), but as now there is no exit from the cylinder, the gas inside it is compressed into the combustion space. This compression proceeds until the piston has reached the top of its stroke, and at this point a spark is caused to pass across the points of the sparking plug J. As soon as this occurs, the gas charge is ignited and expands very rapidly, this expansion forcing the piston B down in the cylinder, and, through the medium of the connecting rod, turning the crank E. This is the power stroke (Fig. 3).



POWER STROKE.



EXHAUST STROKE.

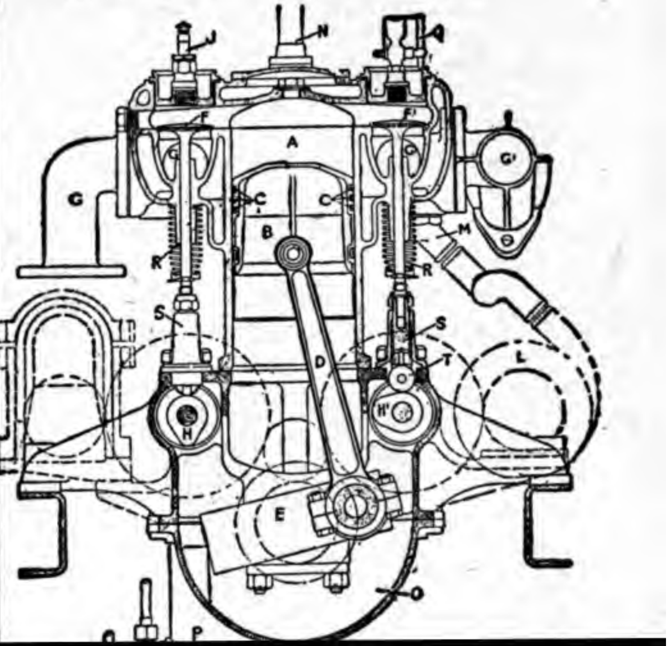
Immediately before the piston reaches the bottom of its stroke, the cam H1 lifts the exhaust valve F1, the inlet valve F, of course, remaining closed. The momentum of the flywheel carries the crank round and forces the piston back up the cylinder, it in turn forcing the exhaust gases out through the exhaust port G1. This is the exhaust stroke (Fig. 4). The engine is now in a position to perform the same cycle of operations as before, the next stroke drawing the piston down and bringing in a fresh charge through the inlet G, which in turn is compressed, ignited and expelled as before. It will thus be seen that the engine during two revolutions has performed the four operations which are necessary to its proper working. The operations in sequence are as follows:

1. Down Stroke of the Piston.—Gas charge is drawn in.
2. Up Stroke of the Piston.—Gas charge is compressed.
3. Down Stroke of the Piston.—Gas charge, being ignited, is violently expanding.
4. Up Stroke of the Piston.—The exhaust gases are being expelled.

These four strokes of the piston, respectively, are known as the Suction, Compression, Power and Exhaust strokes, as indicated under the diagrams.

As the initial operation is to draw in a charge of gas, it will be seen that before the engine can be started it is necessary to rotate the crank shaft so that a charge is drawn in and compressed. This is then fired, and the engine will continue to operate automatically.

The action of the engine being understood from the study of the diagrams, we may now describe a typical automobile engine. The engine may have one or more cylinders. Four is, however, a general number, and the engine which we shall describe is a four-cylindered one. Our illustration is of a four-cylinder 35 H.P. engine. Fig. 5 shows it in cross-section through one cylinder; that is to say, the engine is shown cut in half through the cylinder and valve chests and through the crank case. Here we have again what was described in diagrammatic form in Figs. 1 to 4, but this is the actual arrangement of an efficient and modern automobile engine. Fig. 6 illustrates the same engine in section longitudinally, showing all four cylinders, crank shaft and flywheel. In both these diagrams we shall retain the same letters for the different parts as shown in diagrams Figs. 1 to 4. A is the cylinder; B is the piston with its rings C; D is the connecting rod, and E is the crank. The rings C around the piston are made of spring cast-iron, and by their own springiness they hold tightly up


J
N
Q
F
F'
A
G
G'
C
C
B
M
R
R
S
S
T
D
L
H
H'
E
O
Q
P

against the wall of the cylinder in such a way as to prevent the passage of any gas.

An illustration of a piston is shown at Fig. 5A, though this is not the piston of the engine we are describing. It will be seen that there are three rings in grooves. These rings are slotted, as shown, diagonally. The diagonal slot in the center ring is not shown in our illustration, as it is behind the piston. The rings are normally bigger than the inside of the cylinder, but when contracted so that the diagonal slots are closed up, they will fit inside the cylinder, and will keep tight against it owing to their tendency to spring outward. These slots in the piston are kept an equal distance apart so as to preclude the passage of gas.

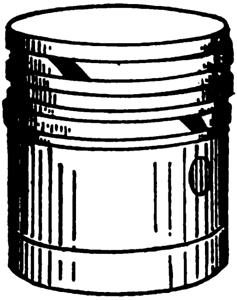


FIG. 5A—PISTON WITH RINGS.

Returning to Fig. 5, F is the inlet valve and F1 the exhaust valve, while G and G1 are, respectively, the inlet and exhaust ports. H is the inlet valve cam, and H1 is the exhaust valve cam. These are on shafts which are driven by gear wheels from the engine, indicated by the dotted lines, but shown in position at Z, Z1 and Z2 in Fig. 6. J is the sparking plug. It will be seen that around the cylinder and around the valves there is a pocket or jacket K (Fig. 6). This jacket is used for keeping the cylinders at a temperature at which the engine will work efficiently, and water is circulated through the jacket from a pump, shown in outline at L, which forces water up through the pipe M and out at the top of the jacket through the pipe N. One jacket is used for one pair of cylinders, and another jacket for the other pair, as is shown quite clearly in Fig. 6.

The crank shaft of the engine is carried in bearings which are fixed in the crank case O. This case is made of aluminum, and not only incloses the engine, cam shafts and gearing, but is also used to assist in the lubrication, which is a most important feature of all internal combustion engines. For this purpose there is an oil pump P driven by the engine, and shown in Fig. 7, to which we shall shortly refer. This pumps oil out of the bottom of the crank case O, and forces it to the various bearings of the engine. At Q is shown a valve, tap or cock, known as the compression cock. By opening this, kerosene can be injected into the cylinder for the purpose of facilitating starting, and at the same time the compression will be released, as, while this is open, the rising piston will force the gas or air out through this valve. It will be seen that the valves, both inlet and exhaust, are kept down on their seats by means of springs R, R. The cams lift them through the medium of plungers S, S, these plungers being arranged with an adjustable screw by means of which the lift of the valves may be regulated. At their ends they carry rollers, one of which is shown at T, and it is against these rollers that the cams work.

Referring now to Fig. 6, which shows the same engine in section longitudinally, we can see the arrangement of the cranks, connecting rods and the gear which drives the two cam shafts—one at either side of the engine. (Here, again, the same reference letters are used to denote similar parts to those in Fig. 5.) In this illustration it can be seen that the two cylinders of each pair are cast in one piece, with one water jacket K surrounding them. This view, of course, does not show the valve chambers, as these are on each side of the cylinders.

Shaft U, as will be seen, runs through three main bearings, V, V, V. These bearings are of special anti-friction metal. At the end of the crank shaft is the flywheel W, which is attached to the crank shaft by means of the flange, formed in

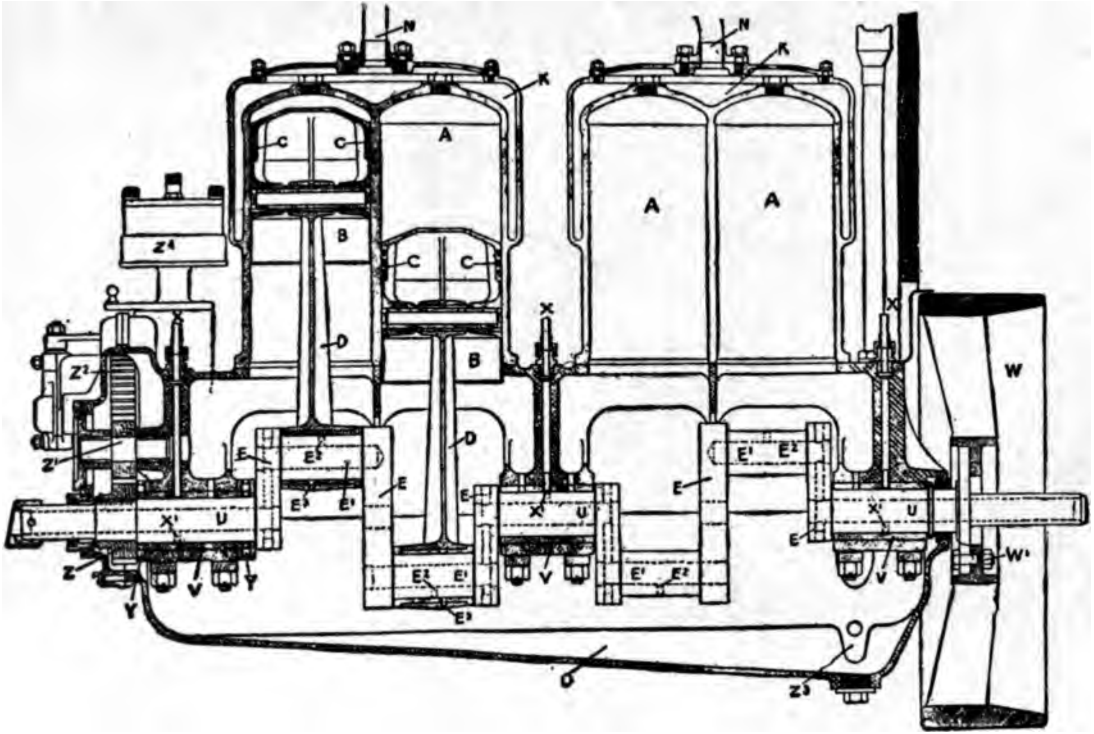


FIG. 6—LONGITUDINAL SECTION OF A 35 H. P. ENGINE.

one with the crank shaft, and the bolts and nuts, one pair of which is shown at W1.

The main bearings are carried in brackets which are suspended from the top of the crank case, and in order to lubricate these there are oil leads X, X, X. These oil leads are connected to the pump (which is illustrated at P in Fig. 5).

In order to take up any end-thrust on the crank shaft when the clutch is released, there are ball-thrust bearings shown at Y just behind the forward main bearing of the engine, and in front of this bearing.

Two connecting rods D, D, from each pair of cylinders, drive on two crank pins between the center and forward bearings, and similarly between the center and after-bearing—this arrangement allowing a very wide bearing to the crank pins.

At Z is shown the pinion wheel which is attached to the end of the crank shaft U. This pinion wheel drives the intermediate pinion Z1, which, in turn, is in gear with two larger gear wheels, one of which is shown at Z2. One of these gear wheels is attached to the inlet valve cam shaft, and the other to the exhaust valve cam shaft.

At Z3 is shown the lowest part of the crank case. It is from this that the oil pump forces up the oil to the different bearings of the engine, the oil naturally gravitating to this end of the crank case.

From this illustration (Fig. 6) will also be seen what is practically the up-to-date practice as regards lubrication. We have seen how the pump lifts the oil from the crank case and carries it to the different bearings of the engine under pressure. The oil enters these bearings by means of the oil pipes or leads X, X, X, and runs down to the main bearings of the crank shaft. Each of these main bearings to the crank shaft is provided with a recessed groove, which comes opposite the end of the oil lead X. The crank shaft itself is hollow, and a radial hole is drilled through the crank shaft into the hollow portion, so as to come opposite the groove in the main bearings. These radial holes are shown at X1, X1, X1.

The oil fed to the bearings is forced through these holes into the central hollow part of the crank shaft, and it then runs up the crank webs E, E, E, E, E, E through holes shown in dotted lines through the center of the crank pins. The crank pins, the crank webs and the crank shaft form one solid piece.

The crank pins are shown at E1, E1, E1 and E1. It will be seen that radial holes E2, E2, E2, E2 supply the lubricant to the big-end bearings of the connecting rod D, the surplus oil being ejected through a hole in the brasses and connecting rod ends, one of which is shown at E3.

At Z4 is shown a case containing a contact maker and high-tension distributer. These are arranged on the top of a vertical shaft driven by skew gear from the inlet cam shaft.

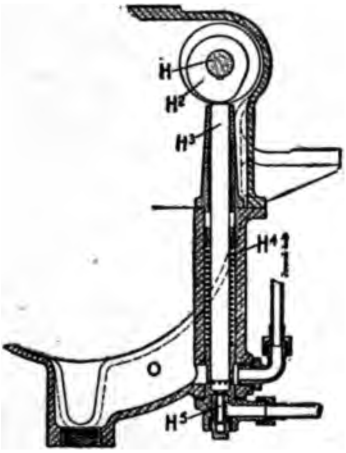


FIG. 7.

FIG. 7—CAM DRIVEN PLUNGER PUMP OF 35 H. P. ENGINE.

In Fig. 7 is an illustration of the oil pump which is arranged inside the crank case O. This pump is driven from the inlet cam shaft H, which, for this purpose, carries another cam H2. This cam comes in contact with the top of the pump plunger H3, which is kept normally pressed up against the cam by the spring H4. At its bottom end this pump plunger, where it enters the pump chamber, has radial holes around it.

As it rises it draws in the oil lying in the bottom of the crank case, and in its descent, by means of the cam, it forces the oil through the delivery valve H5 to the engine.

We have purposely chosen, for illustrating the arrangement of the internal combustion engine, an engine of late design, and one which is fitted to a car which has proved its efficiency. It must be understood, however, that the arrangement of the valves and the cam shafts is not arbitrary, neither is the arrangement of the cylinders in pairs, with water jackets round each pair, exclusively adopted. Some manufacturers arrange the cylinders separately, each with its own water jacket; others cast all four cylinders "en bloc." Then, again, many makers have all valves, both inlet and exhaust, arranged on one side of the engine instead of on opposite sides, as in the case we have illustrated. In this case, of course, only one cam shaft is required.

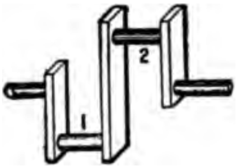


FIG. 8.—TWO-CYLINDER ENGINE WITH CRANKS SET AT 180 DEGS.

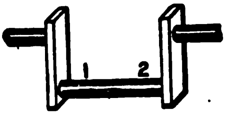


FIG. 9.—TWO-CYLINDER ENGINE WITH CRANKS SET TOGETHER.

As regards the arrangement of the crank shaft, in this there is also a diversity in current practice. In our illustration of the 35 H.P. engine it will be seen that the two pistons nearest the central bearing are descending at the same time, while the two pistons nearest the extreme outside bearings are ascending at the same time. This arrangement may be varied in the case of four-cylindered engines, but is generally the same as in the system illustrated. In some engines the crank shaft bearings are arranged between each crank pin, and some engines have ball-bearing crank shafts. The firing sequence of cylinders in multi-cylindered engines also varies according to the individual ideas of the manufacturer.

The sequence of the firing strokes depends to a certain extent upon the angle at which the cranks on the crank shaft are set. This angle may be either 180, or the cranks may be set together. Where the cranks in a two-cylinder engine are set at 180 degrees (Fig. 8), the two cylinders fire immediately one after another, so that during one revolution there are two impulses, and at the next no impulse. If the cranks are set together (Fig. 9) an impulse occurs at every revolution, but in this case the cranks must be balanced to counteract the vibration set up by all the parts moving in the same direction at the same time.

The following is the sequence in a two-cylinder engine, when the cranks are set at 180 degrees:

First Cylinder.	Second Cylinder.
Suction.	Exhaust.
Compression.	Suction.
Firing.	Compression.
Exhaust.	Firing.

When the cranks are set together, the following is the sequence:

First Cylinder.	Second Cylinder.
Suction.	Firing.
Compression.	Exhaust.
Firing.	Suction.
Exhaust.	Compression.

In the four-cylinder engine the cranks are set at an angle of 180 degrees to each other in the relative positions shown in Fig. 10. This arrangement is such that two impulses are obtained for each revolution of the crank shaft, while the disposition of the cranks is considered to give the best balance in the running of the engine. The firing sequence is—1, 2, 4, 3.

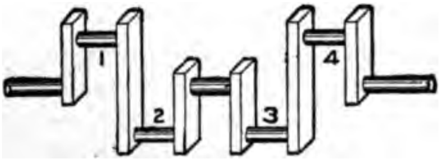


FIG. 10.—FOUR-CYLINDER ENGINE WITH CRANKS SET AT 180 DEGREES.

six-cylinder engine the cranks are set at an angle egrees to each other, the two center crank pins being vith one another. The opinion of engineers differs s to the best firing sequence, as there are a number of possible combinations. For instance, the combina- , 2, 6, 3, 5 is used on the Napier cars, while 1, 5, 3, occasionally used, but is not by any means definitely as the correct one.

cylinder engines are still very much in the minority. the engines are of the V type, with four cylinders at de of the crank shaft.

ler to grasp how the engine transmits the power to wheels, the articles under Gearing and Transmis- o Change Speed Gear) should be carefully studied. ould also advise the beginner to make himself thor- cquainted with the principles of the design and con- of the various vital parts of the engine and the s in different systems, and with this object in view d carefully study the Carbureter, Ignition, Contact Distributer, Sparking Plug, Valves, Cooling, Clutch, crank chamber. There is a pipe leading from the crank chamber to the inside of the cylinder A, this pipe being shown at G. When the piston is at the bottom of its stroke it uncovers the top of the pipe G, so that the cylinder A comes into communication with the crank case O.

P is the exhaust port, which is uncovered by the piston when it reaches the bottom of its stroke. Q is a baffle plate, which, when the piston has opened the top of the pipe G, comes opposite to that opening and directs the incoming gas charge in an upward direction. The cycle of operations is as follows:

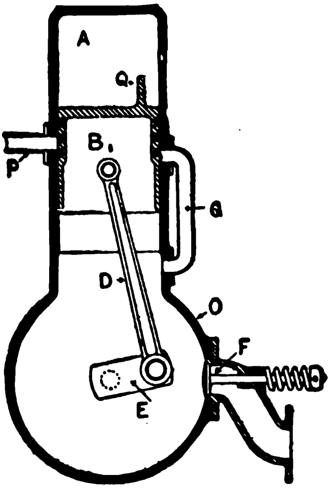


FIG. 11.—A TWO-CYCLE ENGINE.

The first up stroke of the piston draws the charge of gas into the crank case through the valve F. The piston then descends, compressing the gas charge in the crank case. When it reaches that point at which the top of the pipe G is uncovered, the compressed gases in the crank case rush through pipe G into the cylinder A. The piston then ascends, and when it reaches the top of its stroke the charge is fired and the piston descends until it reaches that point at which the exhaust port P is uncovered. This is the power stroke, and during this power stroke another charge of gas, which came into the crank chamber owing to the upward suction of the piston, is being compressed, and just after the exhaust P is opened this compressed charge rushes up through pipe G into cylinder A; the returning piston further compresses it there, and when it is at the top the charge is fired. The incoming charge during the time that the piston B has uncovered both the exhaust port P and the top of G violently pushes the exhaust gases out through P. By this arrangement an impulse is given to the piston on each revolution, so that there is no need for any mechanically operated valve, the only valve being the automatic one at F. Such engines, though not largely used for motor vehicle purposes, are very popular for motor boats, and, in fact, for this purpose have proved themselves to be among the most efficient of internal combustion engines.

ANOTHER VIEW OF THE MOTOR.

There is no magic about a gasolene motor, writes an eminent authority on motoring; it is just a particular kind of gas engine. Gasolene is a petroleum spirit of a certain chemical denomination—one of the hydrocarbons. Coal gas or ordinary illuminating gas is another of the hydrocarbons. Gasolene is a highly volatile spirit, and when its vapor is diluted with a certain proportion of air, it will "combust" with extreme rapidity; in the same way as when the air in a room becomes charged with a certain proportion of coal gas, owing to an escape, the introduction of a naked flame into that room causes an explosion. A motor means that which moves, and an engine means an ingenious machine, generally a motor. It is more usual to speak of a gasolene "motor" and a steam "engine," but the motor and engine are practically alternatives in automobile parlance. So gasolene motor, hydrocarbon motor, explosion motor and internal combustion motor are more or less equivalents, though one would not speak of a motor using alcohol fuel as a gasolene motor, of course, though operating on the same principle. "Internal combustion motor" implies that the fuel is burned in the motor, instead of outside the same in the fire box or furnace of a boiler, as in a steam engine. The apparatus by which the gasolene vapor and air are mixed together is called a carbureter, or carburator, from the fact that by it the air is charged with the hydrocarbon. At the beginning it is enough to know that the gas or mixture is sucked from the carbureter into the engine by the action of the latter.

The Elements of the Motor.

The engine or motor consists primarily of a cylinder, a piston, a crankshaft, and a rod connecting the piston to the crank on the shaft. The cylinder is, of course, hollow and open at one end. The piston slides up and down in the cylinder as the plunger of a tire-pump slides up and down in its barrel. The piston operates on the crank through the connecting rod, pretty much as the cyclist turns the crank of his bicycle by his leg from the knee.

The operation of the gasolene motor differs from that of the cyclist in that, while with the latter an impulse is communicated to the crankshaft at every half revolution, in a single-cylinder gasolene motor there is only one impulse for every other or alternate revolution of the crankshaft.

The motor has a cycle or series of four operations: 1, suction (intake or induction); 2, compression; 3, firing (ignition, combustion, or explosion); and 4, exhaust. They are performed in two revolutions of the crankshaft, corresponding to two outward or downward strokes and two return or upward strokes of the piston.

1, Suction. Suppose the exhaust gases of one charge have just been disposed of, the momentum imparted by the last explosion to the crankshaft (and stored up in the flywheel fixed thereto) causes the crank to descend and to draw down the piston by the connecting rod. As the piston descends, it tends to create a vacuum in the cylinder head, which is called the combustion chamber. The inlet valve opens, either by reason of the suction, or by mechanical means to be explained later. In either case, as the valve opens, the combustible gas vn into the cylinder head through the inlet valve. As ston approaches the end of its downward stroke, the s closed by a spring, and the gas is imprisoned in the stion chamber. But it is no use firing it yet, because it not drive the piston any further if we did, so we must piston return to its other extreme position near the the cylinder. We must not fire it before it gets to the se we shall make the piston return too soon and drive nkshaft round in the reverse direction.

mpression—As the piston rises (still driven by the mo-n), it compresses the gas. This compressing action great demands on the momentum, but it is more than it, because the subsequent impulse is very much more ul than it would be if the gas were not compressed.

ring—When the piston has got back to the top of its the compressed gas is fired by an electric spark. The uent combustion or explosion deals a blow at the top piston which drives it down the cylinder with great When the piston has nearly got to the bottom of this

The De Luxe Carbureter—An Exclusive Design.

Type A.

Type B.

Stromberg Carbureters.

funnel with a very fine gauze strainer should be used, as any solid particles admitted are likely to choke the jet of the carbureter. If the gasolene be poured through a piece of fine cambric laid over and depressed into the top of the funnel, the passage of water will be resisted. Wipe the top of the can clean before opening it. Often the orifice of the can is covered by a screw cap having slots or notches in the top. Such a cap can be turned by the edge of the bottom of another can or by a thin tire lever, or even the edge of the car step—inserted in the notches. The spout of the funnel should not fit the hole in the tank tightly, or the air will not pass freely out of the tank. Some spouts have air-grooves—others may be squeezed slightly to destroy their circular form.

Some Necessary Precautions.

The regulations respecting gasolene should be strictly observed; and the fact that gasolene is about to be kept on the premises—if the case—should be known to your fire insurance company.

The gasolene tank on the car is sometimes set sufficiently high to allow the liquid to gravitate into the carbureter. Where this is not the case, the fuel is forced out of the tank by pressure, obtained from the exhaust of the motor, etc.

Gasolene, though not explosive in its liquid form, is highly inflammable, and no naked light should ever be brought near it. A lighted match idly thrown down has accounted for the destruction of a number of cars. Any leakage in the tank, the carbureter, or the connecting pipe should be immediately repaired—the gasolene having been previously run off and time given for the vapor to thoroughly disperse. Should any gasolene catch light, use one of the special gasolene extinguishers; or failing that, throw sand on at once, or salt, or even flour—anything that will exclude the air. Water is worse than useless, as it only spreads the burning spirit about. Of course, if the fire occurs near or under the car, move the latter away at once.

The Carbureter.

The carbureter may act on any one of three different principles, and be distinguished as a surface, wick, or spray carbureter, accordingly. See Carbureter.

The type almost universal on automobiles is the spray carbureter. In this, the gasolene is drawn through a nozzle or jet by the engine, and as it leaves the jet in the form of spray, it mixes with air which is sucked into the carbureter at the same time. Now, as the air must be charged with a certain proportion of gasolene vapor in order to obtain the best results, it will be apparent that the form and dimensions of the carbureter must be carefully designed, and that the flow of gasolene must be properly regulated. To accomplish the second object, a float valve is employed. Instead of being led directly to the nozzle the gasolene is fed through a pipe into a chamber in which is a float, nearly filling the same. In some carbureters the floats are principally made of cork, but they are generally constructed of thin metal. Pivoted to the top or bottom of the chamber of a typical carbureter are two weighted levers. The outer ends of these levers bear against the float; the inner ends engage in a grooved collar fixed to a wire or needle. This needle has a conical point adapted to fit into a corresponding conical seating at the point where the gasolene enters the chamber. As the gasolene gets deeper in the chamber it raises the float, the outer ends of the levers rise, the inner ends are forced down, and the pointed end of the needle is thrust farther and farther into the seating, so that when the gasolene has reached the desired height in the chamber the supply is cut off. There is a small passage communicating between the float chamber and the nozzle, consequently the gasolene will stand at the same height in the nozzle as in the chamber. Usually the float valve device is arranged to keep the gasolene at about one-sixteenth inch below the level of the top of the jet. This is all very well while the car is on the horizontal, but it will not answer properly on steep hills if the float chamber is arranged behind or in front of the nozzle. Cars sometimes stop on stiff gradients because the gasolene does not rise high enough in the nozzle. When the float chamber is set at one side of the nozzle the difficulty arises that if the car is standing on the side of a heavily-arched or cambered road the level will be upset; and this, if it does not stop a motor that is already running, may make it very difficult to restart, if once stopped. In such a case the car should be moved off the slope, so as to restore the level. In some carbureters this trouble is not so liable to arise, as the float and nozzle are arranged concentrically. In actual running the needle valve practically never closes, but keeps at such a position that it lets through just sufficient gasolene to maintain the proper level in the carbureter.

Carbureter Adjustments.

The air to be carbureted is let in through the bottom or side of the jet chamber, and passes up outside the jet to the inlet valve of the motor. Generally, the air so admitted is purposely overcharged, and the correct mixture is obtained by letting in more air through apertures located somewhere between the jet and the inlet valve of the motor. These apertures can be opened and closed more or less until the desired mixture is obtained. In dry, warm weather the additional air inlets may be opened, perhaps to their fullest extent; in damp, cold weather they may have to be closed entirely. It is desirable that this regulation should be within the control of the driver while traveling, but too often this is not the case. Sometimes, indeed, the maker adjusts the carbureter (presumably to suit the most unfavorable atmospheric conditions), and the user is given no control over it. An attempt is made to imitate the best state of the atmosphere by taking the main air supply from round the exhaust pipe or some other warm neighborhood; or the jet chamber has double walls, and part of the hot exhaust gases or some of the heated "cooling" water is led in between them. Both these devices are useful in, say, foggy or drizzly weather, but they should be quite optional, as a warm charge of mixture is less dense than a cold one, and to get the most out of the engine it is essential that it should take in as dense) a charge as possible. The carburation should adaptable to the prevailing conditions.

r should be introduced into the pipe leading from the tank to the carbureter. This will serve to catch solid which might otherwise be carried up into the jet and it. There should also be a little well with a screw cap below the jet; besides acting as a settling chamber, cap allows for clearing the jet—if of the single ori- —by thrusting up a piece of fine, soft wire. Another nsists of an inverted cone or some other form of baffle over the jet. The object of this is to break up the gasolene as it strikes it, and so help to vaporize the fore starting, the combustion spaces of the motor may practically pure air, and the gasolene standing in the r is probably stale, after evaporation. Hence a harged mixture is required to obtain an explosion. y be obtained by causing the gasolene to overflow f the carbureter. For this purpose the needle valve at chamber must be held open, either by holding up e, if it projects through the top, or by pushing down upset it by taking overdoses of the spirit when going fast or racing, and the reverse when going slowly. The arrangement generally consists of an extra air inlet, normally closed by a spring, but adapted to open proportionately as the suction effect increases with the speed of the engine.

Every carbureter should be fitted with a throttle, that is, a door or valve, by which the quantity of mixture passing to the engine may be regulated. The throttle may be automatically controlled by a governor, and it should be arbitrarily controllable by the driver; the construction being such that the automatic control is subject to the arbitrary or positive. But many modern cars are built without governors.

From the carbureter the mixture passes to the engine through an inlet pipe. This pipe should not be too long—preferably not over 15 inches. Where there are two or more cylinders, the inlet pipe will have to be divided into branches, and these should be so designed that the lengths of the passages to be traversed by the mixture on its way to the respective cylinders are all equal. Simple and speedy means for disconnecting the inlet pipe should be provided at all its terminals. The connections should be gas-tight, otherwise carburation will be interfered with, and unequal results obtained from the different cylinders.

The Engine Proper.

Now we come to the motor itself. The first question to be decided is the number of cylinders. A single-cylinder is naturally the simplest, and, by some, considered most suitable to the novice. It has the disadvantage of being uncomfortable, its intermittent action in many cases setting up a considerable amount of vibration. This defect can be considerably modified by having a large diameter and heavy-rimmed flywheel, but it is much better met by adding to the number of cylinders, so that, for the same power, the impulses may be reduced in force, and increased in frequency. Even the novice is sometimes better off with a multi-cylinder engine, as if a defect in one cylinder baffles him, he still has one or more left to take

:. The smoother running is, of course, better for the
ell as for the occupants. In the two-cylinder motor
lses may be timed to occur either at equal intervals,
every two strokes of the piston and one turn of the
t; or one at a half-turn of the shaft after the other,
it intervals of one stroke and three strokes. The
rangement has the advantage that the "torque," or
orce, of the crankshaft is more regular, while with the
reciprocating parts are better balanced. With three,
six cylinders, these two advantages may be com-
t the complication, weight, and cost are all added to.

Position of Cylinders and Crankshafts.

her general considerations respecting the motor call
on by a prospective purchaser. One is as to whether
lers shall be vertical or horizontal, and the other as
er the crankshaft shall lie lengthwise of or across the
ther point is of vital importance. Vertical cylinders
itudinal crankshafts are by far the more common,
very good cars have horizontal cylinders and trans-

in each groove is placed a piston ring. These rings are generally bored slightly eccentric, and are cut through obliquely at the thinnest part. They are normally a little larger in diameter than the bore of the cylinder, so that they press against the walls of the latter when in action; and at such times the rings should be of perfectly circular form externally, and the cuts or "slots" should be very nearly closed.

Connecting Rod Bearings.

Near the closed end of the piston is mounted a spindle, the gudgeon or piston pin. The upper end of the connecting rod rocks on this pin, and it is important that the pin itself should not move, and that the means for fixing it should not get loose and drop away, or considerable damage may be done. It is not within our scope to detail all the devices that have been employed, but one of the simplest is to form one of the piston ring grooves coincident with the ends of the gudgeon pin which extends right through the walls of the piston. As the piston and connecting rod, being reciprocating parts, are subject to innumerable and sudden reversals of their direction of motion, they should be made as light as possible, consistently with being strong enough to withstand the explosions and convert the impulses into a rotary motion of the crankshaft. The gudgeon pin end of the connecting rod is called the small end, and the other the big end. The journals, or bearings, at the big end are adjustable, so that wear may be taken up from time to time.

The Crank Case.

The crankshaft is mounted in bearings in a casing called the crank case. The case is usually made of aluminum alloy for lightness; and, with bracket extensions, it forms a means of attaching the engine to the frame of the car; it also serves as an oilbath, into which the cranks dip as they rotate and splash the oil about so that a quantity falls into little ducts which lead to the bearings. The crank case should be made with handholes, through which the big end bearings may be adjusted; if they are large enough to allow of withdrawing the piston, so much

er. Another arrangement is to divide the crank case
ally, and fix the crankshaft bearings to the upper part
ase. This allows of the lower portion of the case be-
ched without disturbing anything else, and when this
emoved, those above it can be dealt with as may be
. A combination of the two plans is best; as the
one entails a lot of upside-down working.

e the crankshaft has more than two cranks, there
e a bearing on each side of each pair of cranks, other-
re is a danger of the crankshaft bending, and even
, under its work.

Function of the Half-speed Shaft.

ch operation of the motor happens only once in two
ons of the crankshaft, the firing of the charge and the
of the exhaust valve are controlled by a shaft rotated
the speed of the crankshaft. For this purpose gear
are fixed to the crankshaft and to the "half-speed
hese wheels gear together, and the wheel on the half-
aft has twice as many teeth as the wheel on the crank-

one hand and the exhaust pipe on the other. Sometimes the exhaust valve is arranged directly over the combustion space in the cylinder head, but more often it is arranged in an exhaust valve box at the side of the cylinder. The upper part of the stem works in a guide, and a plate or washer is mounted on the lower part of the stem. Between the guide and the washer there is a strong spring, which normally holds the valve tight down on its seating. The edge of the valve and the seating are generally beveled, and carefully ground to the same angle, so that the valve may be gastight when closed.

It will be remembered that the exhaust valve is only open during one of the return strokes of the piston. This corresponds to half a turn of the crankshaft, and to a quarter of a turn of the half-speed shaft. Hence the hump only occupies about a quarter of the periphery of the cam. In practice, it is found best to allow the exhaust valve to open before the piston has quite finished its driving stroke, and to close exactly at the top of the return stroke. The valve should open fully and close completely as promptly as possible, but each end of the hump must be inclined—the forward end to lift the valve plunger in ordinary running, the rearward end to do the same in case the engine is accidentally reversed. Were it not for this last consideration, the hump might have a radial or precipitous end. Sometimes a hinged arm is interposed between the surface of the cam and the foot of the plunger; this is useful in overcoming the transverse action set up by the inclines when operating directly on the plunger, and (when an adjustable arm is used) in providing means for controlling the motor by varying the lift of the valve. The exhaust passage or port, the valve itself, and the exhaust pipe should be of ample dimensions, so that the exhaust gases may be cleared out with as little resistance as possible. A good many motors are now constructed with a large chamber, into which the exhaust ports of all the cylinders open. This provides for more ready expansion of the gases than if they are led directly into the more or less restricted exhaust pipe.

When the cylinders of the engine are separate castings, the branches of the exhaust pipe should be connected in such a way as to allow for a slight relative movement due to unequal expansion of the cylinders.

Silencing the Exhaust.

The object of the exhaust box is to silence or muffle the noise of the exhaust. At the same time it must allow of the ultimate egress of the gases as freely as possible, otherwise it will set up a back pressure, which will reduce the effective power of the engine. In the box are a number of tubes or plates, which turn the stream of exhaust gases first one way and then another, as in a maze, allowing them all the time to expand more and more, and ultimately allowing them to pass out through a number of fine holes or a pipe. These holes, or the pipe, should not point directly toward the ground; if they do, the exhaust will greatly augment the dust raised; and if they point backward it is very unpleasant for anyone behind, during a block in traffic. The box should be of good dimensions; and should be carried under the back part of the car, so that the occupants may not be troubled by any fumes emitted by it. Do not forget that the exhaust pipe and box get extremely hot, and nothing liable to be damaged by heat (fingers, tires, eatables, etc.) should be brought near them.

The Inlet Valve.

The inlet valve may be opened either by the suction of the piston, or positively like the exhaust valve. In the former case no special mechanism is required; the valve is made very light, and is normally held closed by a comparatively weak spring. Some prefer the automatic valve for high-speed work, and it is certainly simpler than the mechanically-operated valve. Where the latter form is employed, it is operated by a cam on a half-speed shaft like the exhaust valve. In fact, the valve parts can be made duplicates of each other, thus reducing the number of spare parts that should be carried. The contention that an engine with mechanically-operated inlet valves can be run slower than one with automatic inlet valves is to some extent supported by practice; any way, the former are more often used than the latter. But, however the valve is operated, the charge is drawn into the cylinder by the so-called suction of the piston.

The inlet valve is arranged in the port or passage connecting the inlet pipe with the combustion space. When it is located in the cylinder head, and is mechanically operated, the stem is directed upwards, and is operated on by one end of a rocking or see-saw arm, the other end of the arm being actuated by a long plunger rod. More often, however, the inlet valve is set head upward, like the exhaust valve, and is worked by a cam and short plunger. The inlet valves with their boxes may be arranged on the same side of the cylinders as the exhaust valves, in which case they are all operated from cams on a single shaft. This keeps down the number of parts, but crowds them together rather, and generally involves a long and tortuous inlet pipe, in addition to a tendency to unduly heat and therefore rarefy the induced charge. If the inlet valves are arranged on the other side of the cylinders, a second half-speed gear and shaft are necessary, but the various parts are rendered more easily accessible, and the timing of the exhaust and inlet valves can be regulated independently. This timing is a very important matter, as, unless the valves open and close just at the right times, the engine will not give off its full power. The close fitting of the valve head on to its seating is also important, and to facilitate the grinding-in of the valve, the head should be provided with a screwdriver slot. If the valve seatings are detachable, the grinding-in process can be conducted away from the rest of the engine, and the risk of the abrasive material finding its way into the cylinder is avoided.

The inlet and exhaust ports should be short, and, generally, the combustion space should be as free from pockets as possible, as these tend to retain portions of the exhaust gases which mingle with, and deteriorate, the incoming charges of combustible gas. Externally, also, the motor should present a clean appearance, and all fixings should be well secured and readily accessible

ENGINE HINTS AND TIPS.

How to Remove a Broken Screw.

smantling an engine sometimes a screw or stud will ff short, and difficulty will be experienced in removing erally there is not enough projecting metal to enable a ip to be obtained with pliers, so that a saw cut has to be it for a screwdriver. If there is not even enough metal a hole should be drilled vertically in the screw, and the lar or rectangular tang of a file inserted, which will ly obtain sufficient hold to enable the screw to be re- If a left-hand flat drill is used—that is, one cutting -clockwise—this alone will often be sufficient to bring screw. In extreme cases, an alternative is to drill vertically in the screw as before, to tap the hole left-hand thread, and screw it in with a left-hand which, on being screwed up tight, draws out the right- ud.

Another method is as follows: Braze a piece of tool steel to the end of the valve stem; before this has had time to cool, plunge in water to harden it, and grind it to the correct length. This makes a splendid job—in fact, better than new, as the end of the valve stem has a perfectly hard surface, and wears much longer. Also there are fewer loose parts, and consequently less wear than in the method suggested above. An old and attenuated valve treated in this manner will work quite as well as a new valve.

A Cause of Deposit upon Piston Heads.

Many owners have been interested in examining the deposits formed on the piston and cylinder heads, and have been astonished to find that, in many cases, these deposits contained a far larger proportion of mineral matter than of carbon. In one case an owner used five gallons of a certain oil, which only contained mineral matter equal to 0.01 per cent, and yet, after he had finished the whole five gallons, he collected from his cylinders almost one ounce of so-called carbonaceous deposit, which amount did not represent the whole of the deposit, as a complete collection was practically impossible. Now, this one ounce of deposit, on analysis, showed the presence of just over 0.75 ounce of mineral matter, largely of a silicious composition, whereas 0.01 per cent of five gallons of the oil only means 0.07 ounce—therefore the difference, that is, 0.68 ounce of mineral matter, must have come from some external source. The only conclusion that can be arrived at is that some of the dust, which necessarily must be drawn into the cylinders at each suction stroke, is caught by the film of oil as on a flypaper, and so gradually accumulates, forming, with the help of the carbonization which also occurs, a hard cake. Further, it has been found that in the summer this proportion of mineral matter to carbon is greater than in the winter, when there is less dust. And, further, it is noticeable that with an oil that carbonizes badly, the proportion of carbon is much higher in comparison with that of mineral matter.

A Cure for Deposits on Piston.

In another case, an owner coated the top of his engine piston and the combustion chamber (after thoroughly cleaning them) with ordinary plumbago mixed into a paste with gasolene. He ran the car over 9,000 miles, and on taking down the engine found no deposit.

Overheating: Its Causes.

To a novice in motor matters, the overheating of the engine is sometimes the cause of a lot of trouble, either to the driver himself or to the engine. In the first place, the degree of heat which the cylinder attains, together with certain of the water pipes leading thereto, is a source of wonderment and anxiety to the new owner of the car. On the other hand, he may have a little of that knowledge which is proverbially a dangerous thing, and, knowing that the power of the engine is derived from the explosive combustion of a gas drawn into and compressed in the cylinder, he naturally knows that heat is thereby generated, and so long as the heat is there, he is regardless of the consequences. Overheating is attributable to one of the following causes:

1. No water in the tank or circulatory system.
2. Failure of the pump, where used, to act.
3. Air-lock in the water pipes, preventing circulation. This is also liable to happen with the thermosyphon or natural circulation type.
4. Insufficient radiation surface.
5. Using too rich a mixture.
6. Habitually running the engine with the accelerator up, even when the vehicle is traveling at a slow speed.
7. Ignition point too much retarded.
8. Insufficient lubrication.
9. Choking by dust of the gauze (if used) over the main air intake of the carbureter.
10. Wear of the rear wheel bearings, disturbing the relative positions of the brake-shoes and the brake-drums, so causing constant friction.

Certain of the foregoing items also refer to air-cooled motors, particularly Nos. 4 and 5.

1. No Water in the Tank or Circulatory System.—Dealing with the causes in the order given, we find the effect of the first is very quickly to overheat the engine, usually bringing about the burning of the lubricating oil, which is the first indication given of the overheating. This, however, only lasts for a few minutes, and immediately after the engine has been started. Later, a squeaking may be heard, and if the engine is not at once stopped, the inevitable result will be the piston seizing or sticking in the cylinder, thereby causing considerable trouble, and very often serious damage. If it is found that the water has been drained from the circulatory system, and the engine has been unwittingly started up, the latter must be allowed to get quite cold before any water is put in, or at least as cool as the hand can comfortably bear when pressed hard up against the cylinder head. If the water is put in and the temperature is higher than this, the cylinder jacket and the cylinder itself are very liable to fracture; in fact, if cold water is put into the engine in its highest degree of heat, fracture is certain to follow.

2. Failure of the Pump to Act.—This does not usually involve very great risks, as there is invariably some water left in the cylinder jacket, and before this is finally evaporated, overheating is distinctly noticeable as being the cause of a gradual loss of power in the engine. If one has reason to suspect the pump is not working up to its proper state of efficiency it is well to test the circulation by squeezing one of the rubber hose connections on the delivery side of the pump, or to watch the return pipe in the cylinder lead to the tank, and see if the water is flowing from there. To guard against these risks it is always advisable to fix a water circulation indicator —a little instrument which, while inexpensive, is the greatest safeguard one can have against pump troubles.

3. Air-lock in the Water Pipes.—An air-lock in the water circulation is a very troublesome thing, and one which will trouble the amateur perhaps more than anything else in con-

with water-cooling. There are several ways in which lock, or air-pocket, may be formed. By air-lock it is od that air has been drawn into the water pipes, and complete cushion between two bodies of water, which lly prevents its flowing. One of the most frequent f forming an air-lock is putting a fresh supply of wa- the tank when there is a small amount of water run- the pipes which are below the level of the tank. The ushing into these pipes prevents the air escaping, and air-lock is formed. To prevent this, if there is a small of water left in the radiators and connecting pipes to completely away, put in fresh water, allowing the ck to remain open until this flows through. By this re the air will, of course, be driven out of the pipes, through the drain-cock by the force of the water it.

sufficient Radiation Surface.—This is an inherent con- nal defect, but is not always the case, as there are in- where a larger engine has been put into a car without ition being made to the radiators. Therefore, if one loss of power is noticeable. Remedy: Provided the circulation is correct, see that the mixture is not too rich.

6. Habitually Running the Engine with the Accelerator Up.—The habit which many drivers fall into of driving the engine continually at its top speed is one to be deprecated. The effect is increased wear upon the piston and cylinder, owing to the increase in piston speed. Supposing the normal speed of the engine to be 1,000 revolutions per minute, accelerating to 1,200 r. p. m. means that, if the engine is habitually run at 1,200 r. p. m., it makes no less than 12,000 revolutions per hour more than it is intended to do. Acceleration is provided to give an increase of power when required for short intervals. There are, of course, some engines which are designed to run at 1,500 r. p. m., but in these the water circulation is accelerated, and extra special attention is given to lubrication to prevent overheating.

7. Ignition not Sufficiently Advanced.—The mixture is burnt slower and the flame is longer in contact with valves, combustion chamber and piston head. This causes overheating and loss of power. The remedy is to keep the ignition point advanced to a position just short of knocking except when it is desired to run the engine dead slow.

8. Insufficient Lubrication.—The results in this case are similar to those of poor circulation, namely, loss of power. A seized piston with all its attendant evils may result from want of sufficient oil.

9. Choking of Gauze Covering of the Air Intake.—If a wire gauze is used to pass the main supply of air through to the carbureter, in dusty weather this is rather likely to get partially choked up, and thus as less air is allowed through the gauze the suction on the gasolene jet is increased, and therefore a much richer mixture is obtained. The remedy for this is to wash the gauze through with gasolene to remove the dust.

10. Wear of the Rear Wheel Bearings, Disturbing the Relative Positions of the Brake Shoes and Drums.—A more probable cause of overheating is, however, that after a time, more

particularly on live axle cars fitted with internal expanding brakes, a certain amount of wear takes place on the rear wheel bearings, and this allows the wheel to be forced upward relative to the axle sleeve, and since the brake segments are carried on a bracket secured to the sleeve, it follows that the lower portion of the brake segment is lower relatively to the brake-drum. Thus it commences to rub, and consequently the engine has to work as though it were always driving the car up an incline. The same thing applies to external brakes, which may be fitted without any device for removing the brake blocks or bands from contact with the drums when the brakes are supposed to be taken off. All these bands or blocks should be properly fitted with springs and stops, so that they may be automatically and entirely removed from the brake-drum when the braking action is released by the driver.

Precautions Against Overheating.

Overheating in a motor is a serious circumstance, and every precaution should be taken to guard against it, as harm will result unless immediately attended to. The chief symptoms are a loss of power, accompanied by harsh running, steam rising from the cooling water, and premature ignition resulting in a knock in the motor. The causes of overheating may be restated as any one of the following circumstances:

1. Loss of cooling water.
2. Want of oil or imperfect lubrication.
3. Racing the motor for long periods.
4. Continued driving on a low gear with the ignition forward and a large volume of mixture.

This, of course, applies to motors without governors and is equal to racing a governed engine. The remedies are (1) to see that the pump, if used, is working properly, and that no leakage is taking place at any part of the system, and that the water tank is filled and replenished as often as required; (2) fill up the lubricators and see they are working properly, and occasionally wash out the oil tank and pipes with kerosene; keep all the joints tight and free from leakages; (3) refrain from racing the motor unless it is absolutely necessary, such as, for instance, starting on a bad hill; (4) drive on the highest gear you conveniently can, with the throttle as little open as possible, and the sparking advanced. The result is economy in fuel, easy running, and a large reserve of power without changing speed.

Piston Working Dry.

If the engine becomes overheated, a knocking will in all probability be heard. This conveys the impression that the piston pin is loose in the piston, or in its bearing in the connecting rod end, or that the big end brasses (bushings) embracing the crank require adjustment. The knocking is often actually due to the piston working dry in the cylinder, and unless an excessive supply of lubricating oil is at once given and the engine allowed to cool down, there is every possibility that the piston will seize in the cylinder and score it, when an expensive renewal of piston or cylinder, or probably both, will have to be made. Never run the engine to its utmost capacity for a longer period than is absolutely necessary, unless you wish to shorten its life considerably. When the car is on the level or running downhill, the speed desired can be obtained by judiciously advancing the spark and reducing the gas by means of the throttle valve. This at the same time gives economical running.

Fan Belts.

Those whose cars are fitted with fan-cooled radiators with belt-driven fans should give a little attention now and then to the belt, and see that it has not become so loose that there is a good deal of slip, so that the fan does not rotate so rapidly, and consequently does not draw as much air through the radiator as when it was tighter. To run these fans at high rates of speed requires more power than is generally imagined, and if the belt becomes over slack there is undoubtedly the slip we have mentioned, particularly with round belts on V-rimmed pulleys. This was brought home to one owner by the fact that upon several occasions his engine and cooling water seemed hot-a long run than of yore, and he began to suspect either pump or some stoppage in the water circulation. however, that the fan belt was very slack, he tight- vith the result that a certain hissing sound, which had oceeded from the bonnet when the car was standing, and after subsequent runs the engine and the water cool as formerly. But for happening to tighten the night have gone to the trouble and expense of dis- the pump and cleaning out the water conduits.

The Exhaust Cut-out.

mufflers are badly designed, and therefore cause an loss of power, owing to the back pressure caused haust gases being unable to escape freely. Some are an others, the new however being, as a rule, better old. In this case it is a very simple matter to fit an cut-out to a car, while the difference in "life" from e is very great. There are many ways of doing it, , but the simplest method is to fit a flap door to an in the exhaust pipe in front of the muffler, normally ernors generally used in motor-vehicle engines today. Such governors are on the centrifugal principle. It is one of the natural laws that a swiftly rotating body tends to fly from its center. This action is taken advantage of, and the centrifugal governor constructed in a very simple manner. As a rule it will be found that this mechanism is mounted upon the camshaft or layshaft, of the engine, though in one or two instances it is attached to the forward end of the engine crankshaft. Whichever shaft it is put upon it will be found that it consists essentially of two arms at opposite sides of the shaft, which are hinged to a lug firmly keyed to the shaft. These arms carry weights at their opposite ends, and are connected by links to a sleeve, which is free to slide on the shaft. The centrifugal action of the weights is counteracted by means of a spring, the tension of which may be so regulated that the governor may be set to function at any predetermined time. So that when the centrifugal force overcomes the resistance of the spring the governing of the engine begins to take place. There are various forms of the centrifugal governor, but all function in precisely the same manner.

Governing on the Inlet.

In the majority of governed engines of today the governor acts upon a valve placed in the induction or inlet pipe. This valve regulates the amount of gaseous mixture which is allowed to pass through to the cylinders. Many of these throttle valves take the form of a butterfly valve, consisting of a disk, which will close the induction pipe completely when placed at a right angle to the center line of the tube, but which, when in its normal position, that is, horizontal with the tube, causes practically no resistance to the passage of the gas, excepting that which is offered by the thickness of the disk and the spindle upon which it turns. This spindle is fitted with an arm on its outer end, and is connected to the governor sleeve by suitable connections, so that when the governor has overcome the first resisting pressure of the spring it gradually closes the valve. As the engine speed increases, the governor still further compresses the spring, and in so doing closes the throttle valve by bringing the disk more toward a right angle position in the inlet pipe. It will be seen that this is a very simple and effective method of reducing the speed of the engine, preventing it from overracing by simply reducing the volume of mixture passed to the cylinder.

Other methods of reducing the cylinder charge are: (1) By means of one circular chamber working within another, the inner chamber having two orifices, which correspond with those in the outer chamber, which is inserted in the inlet pipe. By revolving the inner chamber the apertures are varied by the inner one reducing their area. (2) Another means is by inserting a chamber in the inlet pipe, in which works a mushroom type valve, the lifting of which regulates the amount of mixture passed.

The Function of the Governor.

The ideal conditions for the working of an internal combustion engine are those in which the speed of the engine shall be such as shall develop just sufficient power to enable it to run smoothly, and at its most efficient speed. When the speed of the engine is reduced, the power decreases in relation to the reduction in speed. In like manner, power increases with the increase of the speed of the engine. It is to prevent the production of more power than is actually needed for the propulsion of a vehicle that the governor is fitted. When the car is running on level ground with a good surface, the engine is working in an economical manner, because the governor only allows of the admission of sufficient gaseous mixture into the cylinders to produce the amount of work that the road conditions call for. So that when the speed of the vehicle, and with it the engine, is reduced, as when surmounting grades, the governor opens wider and admits more mixture, thus keeping up the speed of the engine.

Governor Setting.

Persistent hunting or racing of the engine is by no means an infrequent source of unsatisfactory running, militating against comfort, economy and flexibility. The matter is one which it is difficult to remedy, in that the trouble commonly lies in the tension of the governor springs being either too great or too small. Springs with small variations in tension are difficult to obtain, at least in a graduated ascending scale of strengths, and consequently it is found that, whereas the original spring permitted the governor to act unduly at the slightest speed variation, the new spring practically obliterates the action of the governor, and the engine is difficult to control, although the difference in the two springs may be apparently very small. In adjusting the governor springs, one has, of course, to vary the adjustment according to the location of the spring. In some engines the springs are set across the points of the governor weights and revolve with them. With other patterns the spring is set between a sliding collar and a top on the shaft, and there are various other methods.

Trouble with Distorted or Sticking Valves.

There are times when misfiring takes place at intervals and the ignition appears to be at fault, but it may prove to be that owing to overheating the exhaust valve has become distorted or pitted on its seat, or the stem is slightly binding in its guide. The symptoms are very similar. In the first place it will require carefully truing up in a light lathe, care being taken to preserve the correct angle of the valve seating, and to keep it absolutely true and straight with the stem, the slightest eccentricity of one with the other being fatal to the running of the motor. If pitted badly it will also require turning in the lathe and grinding-in afterwards, or if slightly pitted, grinding-in only will suffice, fine flour of emery and common lubricating oil only being required. To cure the sticking stem, smoothen it up with fine emery cloth to slightly reduce the diameter and remove the roughness, oil slightly, and replace after grinding in the seat. If the valve stem becomes slightly bent in any way it is sure to stick. It is better to put in a new true valve at once, if the old one cannot be made perfectly true.

A Cure for Engine Knocking.

ill take a typical case of an engine which, on hills,
l suddenly to lose its power, and when the spark was
htly advanced to develop a very bad knocking. When
ne was stopped it was quite impossible to distinguish
e parts or loss of compression in either the rings or
es; all seemed perfect. However, a point was noticed
ight account for the loss of power when on hills. The
valve stem had very little clearance between its bot-
the valve tappet, and on carefully noticing the engine
orking it was discovered that this valve stem so in-
in length with the heat that it just touched the valve
hen the exhaust valve was near its seating; hence it
t close properly under the action of the exhaust valve
Upon slightly filing the tappet so as to give a little
arance between the bottom of the valve stem and the
he engine was found to pull as well as ever it did, and,
ore, the knock had entirely ceased. Evidently this
hat the knock had been due to the slight escape past
ust valve on the explosion stroke, owing to the tap-

Another Cause.

From time to time one comes across or hears of an engine which has developed a mysterious knock, for which no advanced ignition, or play in the bearings, big end, or gudgeon pin can be brought to account. In all probability no such shortcomings are at the bottom of that irritating tapping, but on the piston top and walls of the combustion chamber there is a thickish deposit of carbon. Clean this all off, and it is probable that the knock will disappear. In the case of such an unaccountable development it is easier to begin by clearing off the deposit if the heads are separate from the cylinder.

Squeaking Noises.

Should an engine develop any peculiar squeaking noises, it is as well to look to the seat of the inlet valve and to the stem of the exhaust valve. The latter is a source of many squeaking noises.

Loss of Engine Power.

When compression is good and ignition right, but at the same time the engine will not pull up to its form, there is very little doubt that the carbureter is at fault. When running light, that is, out of gear, the engine will turn splendidly. It may obey the throttle or accelerator instantly and show every evidence of life, and yet as soon as it is driving the car it will fail miserably directly there is any work to do. The reason the engine runs well when there is no load is because it has practically nothing to overcome except its own weight and friction, so that a very small supply of explosive mixture will keep it running at racing speed. In a recent case of this kind the autoist, after trying everything he could think of, found that the loss of power was due to the rod which worked the throttle being loose. He had never detected that the throttle, when apparently wide open, so far as the positions of the hand lever and the governor lever were concerned, was not really giving full aperture, and consequently the engine was being starved. In this case, not only had a great many engine adjustments been made, but the carbureter had been examined, reason the cause was not detected was because the rod perated the throttle was close up against the frame, ost out of sight. As there are many cars in which ds, for convenience, are placed well out of the way, xperience which should not be forgotten.

Overheated Bearings.

the main bearings and big end of the connecting rod are scraped in when new or after running some con- time, it is necessary to take up the wear and rescrape ings after a greater or less period. On again running r, it is sometimes found that there is a tendency to the bearings, and liberal supplies of oil must be given binding. It will be found that if after scraping in the and before putting on lubricating oil, the wearing sur- well rubbed with flaked graphite, they will run much nd will not have the same tendency to heat up. When d under a microscope the bushings appear to be porous, e up of more or less sharp crystals. The effect of the appears to be that the pores are filled up with this material and a smooth surface formed, friction thus turn the starting handle rapidly, and the key will probably be thrown on to the top of the exhaust valve. Another way, and a less fatiguing one, is to replace the lost key with another and start the motor up slowly, leaving the car inclined as before. After the engine has run a minute or two, detach the pipe, and in all probability the key will be found on the top of the exhaust valve, provided the car is sufficiently tilted. On no account must the key be left in the cylinder. By constant hammering against the head of the piston or the top of the cylinder, the key will be reduced to a ball, and may eventually find its way out down the exhaust pipe and into the muffler, but as it is hardened, it may do considerable damage to the cylinder walls before this takes place. In the case of a two-cylinder engine the operation is easier. All that is required is to detach the sparking plug from the cylinder in which the key is lost, and start up the engine. In a very short time the key will most likely be thrown out through the sparking plug hole. The car must be left in the inclined position.

Hissing Noises.

If an engine develops a peculiar whistling sound, which is accompanied by a noticeable loss of power, any joints which may be made in the cylinder head should be tested for tightness. Such joints may be found at the sparking plug or tappet in low-tension magneto-fired engines, the caps which cover the valves and compression relief cocks. The best way to test for leakage—provided it cannot be found by feeling with the hand—is to run a little lubricating oil round the joints to be tested, and then run the engine. Any escape will, of course, form bubbles in the oil, and so the point of escape is located.

A further cause, which might result in considerable damage being done, and which is very difficult to locate, is that of an open, or lost, oil drain-cock in the crank chamber. As this is generally out of sight, it is similarly out of mind, and in consequence a driver may continue on his way until he is pulled up by a seized piston. A blown exhaust-pipe joint or loosened nuts on the exhaust system are usually accompanied by a sharp hissing or crackling, and can generally be put right in a few minutes.

On Fitting Piston Rings: Signs of Bad Rings.

A loss of compression means a loss of power. To discover the cause of this loss of power is one of those things which often baffle the motorist, even though he has got through the novitiate stage. Loss of compression is liable to be caused by several things—for instance, leaky inlet and exhaust valves, a badly-fitting combustion head (in cases where the head is separate from the cylinder barrel), or by badly-fitting piston rings. It is with these latter that we will deal at the present time. Supposing that we have a single-cylinder engine, whose compression is bad; the valves have been taken out and ground in to a perfect fit (no difficult job); the joint at the combustion head has been examined, and there is no doubt that this is perfect, but still the compression is bad. This points to the fact that the piston rings need some attention. It is therefore necessary to disconnect the cylinder entirely from the crank chamber, so that when the former is removed, it leaves the piston attached to its connecting rod. Care should be exercised when removing the cylinder not to disturb the piston rings, but to note the relative position of the slots in these as the cylinder comes off. If the slots in the rings are approximately in line, this in itself is sufficient to cause a loss of compression without the rings being absolutely bad. The internal combustion motor, as a rule, is fitted with three piston rings, and the slots of these should be equidistant from one another, to insure there being no leakage past them.

The Cylinder Removed.

The cylinder now being removed, we are enabled to examine carefully the piston and its rings, and provided that the slots in the rings have not been opposite to one another, we now have to look for the cause of the trouble. If the rings are bad, the points at which the gas has been escaping by the piston and rings will be denoted by a burnt or brown or roughened surface on the polished surface of the piston, and the rings.

It will frequently be found that these places occur near the slots in the rings, these being quite discolored for perhaps a quarter of an inch from each end of the slot; or it may be that one ring has not been really true when it was first put in, and it has allowed the gas to escape in small quantities at first. Continued compression of the gas has caused an increasing escape, until quite a large area of escape has been created. This, as in the other case, will be noted by the discoloring of the ring.

The Removal of the Rings.

Having discovered the bad ring or rings, their removal is the next question with which we have to deal. The rings being bad, it is practically immaterial whether they are broken or not in the process of their removal, but we would advise those who are fitting new rings for the first time to be very careful in the removal, as the experience thus gained will be of benefit to them in replacing the new rings. Two pairs of hands are really required to carry out the operation successfully, though with a little extra caution and trouble it may be equally efficiently carried out by one person. The first thing to do is to open the ring by springing the ends apart at the slot, and this is best done by means of two implements; practically anything will do that will fit into the groove of the piston. These being inserted into the slot in the ring, they are gently forced apart, so that the ring is expanded. Then, by inserting a finger or fingers between the implement the left hand can be passed round to the opposite side of the cylinder, and the ring lifted, so that it rests upon the edge of the groove. It can then be forced gently off the piston. In removing the middle ring, care will have to be taken, or the ring will drop into the groove vacated by the top ring. If this does happen, it will, of course, have to be removed in the manner before mentioned. In many instances, the bottom ring can be slid over the trunk of the piston and sprung open sufficiently to pass over the connecting rod, thus saving the possibility of its falling into the two grooves above, and the subsequent trouble of its removal.

Form of Piston Ring.

the rings are removed, it may be noticed that they
of the same thickness all the way round, but that the
the ring is slightly eccentric, and the slot in the ring
d at the thinnest part. These rings, it may be stated,
ed from fine gray cast-iron, this having proved, after
ears of experimenting, to be the best metal from which
gs can be constructed. This form is given to the ring
give it a certain amount of spring, by means of which
of its own accord keep in close contact with the walls
ylinder.

not without interest to know how these rings are
nd, therefore, we give a brief resumé of their construc-
concentric ring is turned off a suitable iron casting
at larger than the finished size required. The rings
ained are split open at any point, and a given length
from the circle. They are then closed together by
rced into a piece of tube, in which state they, of course,
untrue circle. The tube with the rings, in which all
s are in a line, is passed on to a bar provided with a

ring should just fit easily, but not too much so, and on no account should one which is at all tight in its groove be fitted in that condition. It should be laid flat upon the piece of emery cloth and carefully rubbed down until it fits the groove it is to occupy. It is advisable to fit each ring individually, in order to insure its not eventually finding a position in another groove.

We next have to turn attention to fitting the ring into the cylinder itself. The ring should be pushed at least an inch up the cylinder, and should be sprung outward with the finger. If the ring is not of correct diameter, but slightly larger than the cylinder bore, this will be shown at the angular slot by the edges of the ring being out of line. Now take the fine file and carefully remove from the slot a small quantity of metal, being particularly careful to keep the edges of the slot parallel. Sufficient metal must be removed, little by little, until the edges of the ring come into line. The ring is now ready to place in its position upon the piston.

When fitting new rings a slight space should be left between the ends of the ring, otherwise, when the ring gets hot, the expansion may cause the ends to abut and to jam in the cylinder; this jamming being sometimes sufficient to stop the engine. This defect is liable to puzzle the novice badly, as the moment the engine stops the heat passes from the rings into the surrounding metal, and the engine becomes quite free.

Replacing the Rings.

Very great care is necessary in placing the rings in position upon the piston, as, owing to the nature of the metal, they are very liable to break, and this seems to be more the case with new rings than with old ones. It is probably accounted for by the fact that the heat to which they have been subjected while running has tended to make them more springy. The bottom ring should be placed in position first, and it may be possible to open this sufficiently to pass it over the connecting rod. If this is not the case, it must be passed over from the top of the piston, and by a little careful maneuvering and taking it down over the two top grooves a little skew-wise it may be dropped into the bottom groove without trouble. The middle and top rings may then be put into position. A warning note should be given that it will be found more troublesome if the top ring is put in first, trusting to put in the second and third ring over it, than the method just detailed. It will be very apparent if one thinks for a moment that it would be difficult to spring the top ring close in and at the same time pass another ring over it. The inexperienced man has often been seen to attempt this method, but eventually to give it up, as the other method is far more expeditious and satisfactory.

Replacing the Cylinder.

We are now ready to replace the cylinder, but before doing this the slots in the piston rings must be placed at points equidistant from one another, and care should be exercised that they maintain this position. Nearly every cylinder is slightly bell-mouthed at its bottom end, and this is done chiefly to facilitate the insertion of the piston and its rings. This, again, is really an operation which demands two pairs of hands—one person to drop the cylinder into position, and the other to close the rings in as they enter the cylinder. Single-handed, this is a somewhat difficult operation, and is likely to be attended with a shifting of the piston rings, so that one is never really satisfied that the slots in the rings are in their correct position. The cylinder being bolted down to the crank chamber and all the connections made, a dose of new clean lubricating oil should be inserted in the crank chamber and the motor started up.

On first running, it will be noticed that the compression is very bad indeed, which to the novice is a very uncomfortable result, for after fitting new tight rings he naturally expects at the outset to find a very high compression, and the motor difficult to turn in starting up. It must be remembered that the surfaces of the rings when new are in a rough condition on their face, and that they do not attain their best form until they have assumed the glass-like face which may be noticed upon the inside of the cylinder and upon the greater portion of the old rings. This surface can only be obtained by working, and, therefore, it is advisable to run the motor for some time in order to permit of the rings gaining this finished state before the car is actually used upon the road. It is advisable, too, when running the piston rings in to over-lubricate the engine slightly, and to renew the charge at frequent intervals. Supposing that we work the motor for two or three hours by itself, it will still perhaps take thirty or forty miles on the road before the engine picks up its full power. If the rings have been properly fitted and the engine kept well lubricated, many hundreds of miles—perhaps running into several thousands—may be covered before the engine will require a new set of piston rings.

Side Lights on Piston Rings.

It may appear curious to some that cast-iron should be the best metal from which to make piston rings. As we before mentioned, many experiments have been made from the time engines first came into use until the present day, and they are still being continued to find a better metal for the purpose. Hundreds of valid patents on piston rings are now in existence. All these, of course, do not apply to the internal combustion engine, but cover spring or other piston rings used in steam engines.

Piston ring troubles are less frequent with larger size engines than with the smaller ones. The trouble appears to increase as the size of the engine decreases, so that in this matter a little bicycle motor will give far more trouble than a big four or six cylinder high-powered engine.

CHAPTER III.

A TYPICAL MODERN MOTOR.

ollowing is a detailed description of a typical up-to-pressure to make sure that there are no minute leaks or imperfections; they are also subjected to a sand blast and then hand-filed, a final coat of black paint producing a very neat and durable finish.

"The cylinder castings are bored, two cuts being taken, the boring tool moving very slowly so as not to cause the walls of the cylinders to spring away from it. The final finish is by grinding with a carborundum wheel to within 1-1000 of an inch. The cylinders are securely bolted to the manganese bronze motor base, forming a structure of the greatest strength and stiffness.

"The pistons are cast from selected gray iron, are sand blasted and hand-filed inside so as to smooth the surfaces and prevent any rough and partially loose metal from working into the bearings of the engine. Each piston is ground to exact size, being tapered slightly at the upper end to allow for the expansion due to heat. The piston rings are first turned eccentric in a lathe and then cut at an angle of 45 degrees, after which they are compressed to circular form, held in a fixture and ground all over. After this the rings are placed in a "piston and cylinder" finishing machine and lapped with an abrasive compound to exact size, so that when they are installed in the cylinders they fit perfectly. This is an up-to-date feature and is an example of the carefulness exercised in the construction of the car in question to insure the best results.

"The connecting rods are drop-forgings in "I" beam section, the small end bearing consisting of a hardened steel bushing, ground and lapped to size; and the wrist pins are also of hardened steel ground to size. The wrist pin is secured by a very ingenious method and is absolutely prevented from working loose.

"The crankshaft is machined from a bar of alloy steel shaped into rough form on a hydraulic forge and then heat treated; the machine operations are all accomplished with the greatest care, each crankshaft being sent to the inspection department after each important operation. The crankshaft is finished all over and the bearings are ground with carborundum to within 1-1000 of an inch.

"A new feature of particular interest is the method of finishing the connecting rod bearings and the main bearings of the motor. The material used is white bronze, and the bearings are first set up a little smaller than the exact size and a long, slightly tapered and highly polished steel mandrel is slowly forced through the bearing, an operation which compresses and solidifies the comparatively soft white bronze and gives it a high polish. After this a mandrel of slightly larger diameter is forced through—four mandrels in all being employed, the last one compressing the bearing to exact size. This operation does away with hand scraping and produces a more exact and better finish and furthermore has the advantage of leaving a hardened and highly polished surface on the bearing, which renders any adjustment unnecessary for a long period of time. The bearings are grooved to facilitate lubrication and the crankshaft is also provided with oil ways, so that each bearing is thoroughly coated with lubricant at all times.

"The valves are of the mechanically operated interchangeable type, being located on opposite sides of the motor—a neat and symmetrical arrangement and one which does not limit the size of the valve. The camshafts which operate these valves are completely inclosed and each is provided with five bearings constantly kept lubricated by splash from the crank case; the admission camshaft carries the igniter cams which are of the spiral type, all cams being integral with the shaft and not forced on or keyed on, as is so often done. The admission camshaft is machined square at the front end and slides in a square hole in a sleeve attached to the admission camshaft gear, therefore, by suitable mechanism, the entire admission camshaft can be moved backward or forward in its bearings. This causes a different portion of the spiral igniter cam to slide under the roller, and thus the time of the spark is varied—an extremely simple arrangement and one which does away with many parts.

"The exhaust passes into a manifold, the rear end of which is secured to a pipe of large diameter which runs the length of the car to a muffler which is placed transversely and equipped with a cut-out valve so that the exhaust may be directed to the atmosphere if desired, and not sent through the muffler.

"Each motor is assembled very carefully, and when finished is flooded with oil and run by belt for a considerable period until it is ready to be placed on the test stand proper and run under its own power. The test of the motor consists in bolting it to a special stand and running it under its own power, at first very slowly, the conditions approximating those of regular service as nearly as possible. After the motor has run thus for a suitable time it is engaged with a clutch attached to the armature shaft of the dynamo; thus the motor drives the dynamo and develops electrical power in proportion to the speed at which it runs and the measure of which power is obtained by taking readings from a voltmeter and ammeter, multiplying these together and dividing the product by the predetermined constant of the dynamo. This is an excellent and practical comparative test. Each motor is gradually worked up to its full power, and run for a specified time, after which it is passed by the testing department."

CHAPTER IV.

GOVERNING AND GOVERNORS.

ing—Governing is a term used to describe various of regulating the speed of the engine, which need sarily, however, be accomplished by any of the many ces included under the general term "governor."

ity, silence and economy in consumption have ngrossed the attention of motor manufacturers of , and with most satisfactory results. In attaining s perfect control of the speed of the engine was the ect aimed at, and to secure this perfect control the r question had first to be tackled. The difficulty was

We will now describe under five heads the various systems of governing, beginning with the oldest (which is still partially in operation) and concluding with the most modern. The following are the systems: 1. By varying the timing of the spark. 2. By retention of the exhaust gases. 3. By retention of part of the exhaust gases. 4. By complete cut out of the fuel supply. 5. By reduction in the volume of fuel.

(1) By Varying the Timing of the Spark.

This system of governing is almost out of date, except in combination with the throttle. It is an axiom which our readers may take for granted, that to get the best results from the expansion which follows the firing of the charge in the combustion chamber it is necessary that the mixture should be perfect, the compression at its maximum, and that the force of the expansion should be applied just as the piston begins to descend. The power of the explosion can, therefore, be varied by retarding the ignition so that the firing takes place when the piston has descended to a greater or lesser extent in the cylinder. The disadvantages of this system are as follows: It is wasteful, for two reasons; first, because the period during which the power is exerted is reduced, and secondly, because the compression becomes less as the piston descends, and consequently the force of the expansion becomes less also. It overheats the engine because combustion is not completed by the time the exhaust valve opens, and therefore a flame rushes through the exhaust port. For the same reason it damages the exhaust valve, rendering frequent grindings necessary. Finally, on account of the imperfect combustion, the plugs and valves are fouled. Even in the case of single-cylinder cycles, a throttle valve is fitted, and the driver should endeavor to check his pace by means of this valve and the exhaust valve lifter rather than by retarding his ignition unduly. Of course, if it is necessary to travel at a crawling pace, as in traffic, he may have to retard his ignition to the utmost; but under normal conditions the throttle valve will be found to regulate the pace satisfactorily.

st cars fitted with mechanical governors the ignition anged that it can be advanced or retarded, but on nt should this method of reducing the force of the be made use of solely for governing purposes. The ll find it good practice to keep his ignition lever for part in a normal position. If, however, he is running engine at its very topmost speed, he may advance ion so as to insure the explosion taking place when n is in the most favorable position. On the other the engine is running slowly he may retard it to a tent, but not sufficiently to seriously affect the compor to interfere with the perfect combustion of the

(2) By Retention of the Exhaust Gases.

years ago this system was in almost universal use. as become obsolete, but at the same time there are s on the market which are governed in this manner. consists in temporarily preventing one or both exves from opening when the speed of the engine certain point. As a result one or both combustion

combustion chamber. The compression, however, is still maintained at its maximum, and therefore the system makes for economy. The engine is not overheated, as it would be if a full charge were admitted, and the combustion is good. Some authorities maintain that the mixture which enters the combustion chamber under these circumstances has not time to mingle with the waste products of the previous explosion, but the personal experience of many owners shows that the system is successful. Both noise and power are reduced instantaneously, while the moment the foot is raised the car bounds forward once more.

Fig. 1 gives a good idea of this system. E is the cam which lifts the exhaust valve, of which the plunger F is shown. This cam does not act directly on the stem of the exhaust valve, but on the roller D at the end of the rocker B which is pivoted eccentrically on a disk A, which in turn is moved by the foot-controlled pedal. Normally, the eccentric A is so placed that the rocker B is at its highest point, and thus at each revolution of the cam the exhaust valve is opened to its fullest. When the pedal is depressed, however, the disk A is revolved from right to left, thus pushing the rocker B forward so that

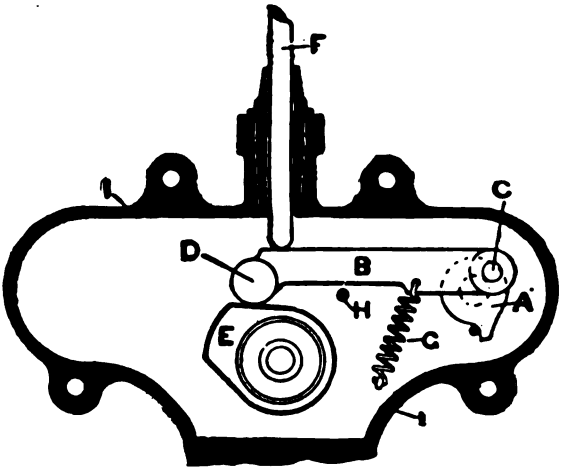


FIG. 1.—THE DE DION EXHAUST VALVE REGULATOR.

reaches the roller D, at a later point in its revolu-
herefore a lesser lift is given to the plunger F. Ac-
the amount of motion given to A the lift of the
lve is regulated. H is the stop on which the rocker
en at its lowest, and the spring G maintains rocker
ion. In the diagram, the cam E is just leaving the

By Complete Cut-out of the Fuel Supply.

anchester 2-cylinder engine the governing arrange-
tained by suspending the action of the feed valve,
ing the engine from using a fresh charge of gas.
ected by a type of hit-and-miss governor, which de-
nertia for its action. This method of governing is
sensitive, and the sluggishness common to many
r forms of governor is absent.

5) By Reduction in the Volume of Fuel.

he most usual system of governing. There are sev-
in use by which the reduction of the fuel charge
to provide the governing effect may be accom-

B, which consequently revolves with it. O, O are the governing weights which are attached to B by arms working freely on studs, and which have continuations Q, Q at right angles to them. The ends of Q, Q bear against the sleeve C, which is free to slide on the shaft A when pressure is applied, but which is normally pushed against the arms Q, Q by the spring S.

P is the spring connecting the weights O, O, and tends to draw these weights towards each other. In the chamber or pipe Y is a butterfly throttle valve, which governs the admission of the mixture to the combustion chamber. The object of the governor is to control this butterfly valve, which it does in the following manner:

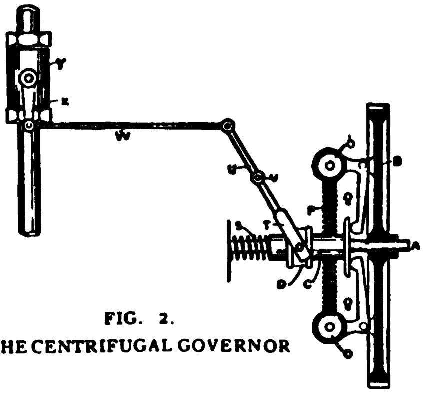
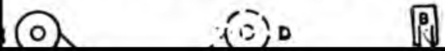


FIG. 2.
THE CENTRIFUGAL GOVERNOR

The spring S is so adjusted as to hold the sleeve C against the arms Q, Q, until the engine reaches a certain pace, while, by means of an accelerator in the shape of a hand or foot lever, the spring S can be assisted to hold back the sleeve C. Now, so long as this sleeve is held against the arms Q, Q, the governor does not come into action, and the throttle valve remains fully open. When the engine is started, the gear wheel B, and with it the weights O, O, revolve, and centrifugal force tends to make the latter fly outward, a tendency which is resisted by the spring P. As the speed of the engine increases, however, the centrifugal force overcomes the resiste spring P; the weights fly out, and the arms Q, Q, inst the sleeve C. A further increase of speed causes centrifugal force, which, at a certain point, over- resistance of the spring S, the sleeve C moves along nd the throttle valve begins to shut, and so reduces e admitted to the combustion chamber. This has of slowing the engine slightly, and the throttle in, either partially or wholly, according as the driver his accelerator.

ustration plainly shows the general principle on centrifugal force is conveyed from the governing the throttle valve. The arms Q, Q push the sleeve eve C actuates fork T on the rod U, which is pivoted e rod W connects U to the throttle lever X, and so fly valve inside Y is operated.

completes the explanation of the system of govern- e throttle which is the most commonly used in one nother. A plate of metal, circular in shape, is at-



dotted lines as at C and D show the valve closed and the relative position of the actuating lever.

Hunting—This brings us to the second difficulty already alluded to, which motor manufacturers have had to face in their endeavors to produce a flexible and silent engine. We refer to the condition called "hunting." By this term is meant the sudden burst of speed caused in some cars when the governor balls fly back to their normal position and allow the throttle to open fully, followed by the no less sudden drop when the increase of speed causes the governor to come suddenly into operation again. This peculiarity is due to the fact that the centrifugal action which gives motion to the governor weights does not follow the straight line law. In other words, supposing the engine to be running at from 300 to 400 revolutions, and the outward movement of the weights against the action of the spring or springs to be ½ in. for an increase of speed of 100 revolutions, the motion for a similar acceleration—with the engine running from 1,000 to 1,100 revolutions—might be only ⅛ in., seeing that not only the angle of the weights about their fulcrum, but the strength of the spring, has altered as the speed of the engine increased. In some engines this action is very pronounced on the lower speeds, and causes the car to rush forward and check again with a suddenness which is very disconcerting.

In some cases no mechanical governor is fitted, but the throttle is worked by hand, in combination with the ignition, and so varies the speed of the engine.

(b) By Varying the Tension of the Inlet Valve Spring—This system has been in use on the continent of Europe, but is now almost obsolete there. It operates by automatically adjusting the inlet valve spring.

(c) By Reducing the Lift of the Inlet Valve—This is an effective and economical method. The modus operandi is simple. The cams for lifting the inlet valves are mounted on a steel sleeve, which is capable of sliding freely along the half-speed shaft of the motor. These cams are tapered from l, so that the valve opens to its maximum when one he cam is beneath the plunger which acts on the n, and the valve lift is at its minimum when the t is reached. In some cases the sliding motion of is attained by connecting the sleeve with the gov- h the result that the lift of the valve depends on the he engine, and consequently the amount of mixture to the combustion chamber is regulated according rk to be done. In this system the compression is proportion as the lift of the valve is reduced, but to a serious extent.

the greatest advantages of this system consists in hat the errors in the ordinary governing device can ted. We have already pointed out that "hunting" on fault with the ordinary centrifugal governor, and ribed the meaning of the term. Where a sliding ying tapered cams is used, as above described, for the lift of the valve, the irregularity in the action ntrifugal governor can be, to a great extent, com- or by decreasing the difference in diameter of these the inlet valves from opening and causes the exhaust valves to open on each down stroke of the piston, thus turning the engine into an air compressor affording a powerful brake.

(d) By Reducing the Time of Opening of the Inlet Valve—In this system there is a special device for directly varying the time of opening of the inlet valve. It affects both the opening and the shutting of the valve, and its action approximates to the cut-off of a steam engine. Needless to say, it curtails the volume of gas in the cylinder, so that the compression is reduced.

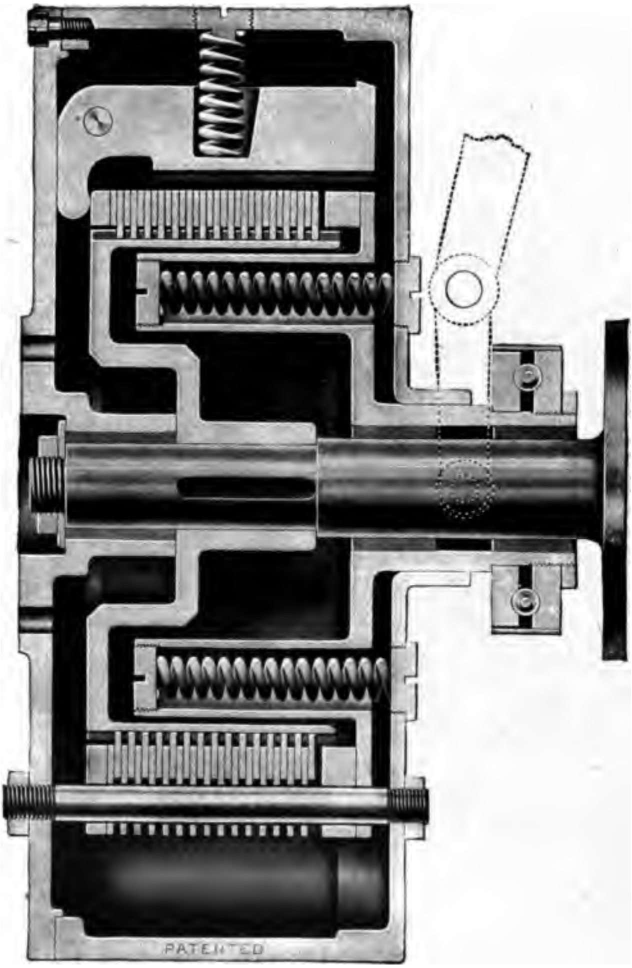
None of these varied systems are absolutely perfect. In the opinion of well-known authorities on gas engine design, the ideal arrangement would be to have a small quantity of perfect mixture round the ignition points, while the rest of the charge required to provide the normal compression should be simply air. The operation of the governor would vary the quantity of mixture admitted, in addition to this air.

Governing and Control—In addition to the means provided for controlling the speed and power of the motor by hand, many cars are fitted with an automatic governor. This generally takes its action from two balls or weights linked to one of the revolving spindles of the motor, and also linked to a collar or sleeve sliding on the same spindle. The weights are normally held close in to the spindle by springs, but as the speed of rotation increases, the weights fly outward more or less, and in so doing move the collar lengthwise. The collar is generally connected to the throttle, so that when a certain speed is reached the governor begins to cut down the supply of gas. This slows the motor, the weights return inward, the collar moves back, and the throttle is again opened, so that the motor picks up its speed once more. When these changes keep repeating the governor is said to "hunt," and it shows that it is badly designed. See under Governing above. A governor that works properly finds and preserves an even balance of the different parts affected.

Some governors are adapted to act on the valve gear so as to modify the operation of the valves. Thus, the governor ntrol the motor by cutting out the lifting mechanism or more of the exhaust valves; or by varying the lift nlet or of the exhaust valves. The cams on the half-haft may be taper, and the shaft itself movable length- the governor in order to produce this last action. governor may be adjusted to operate at higher or lower by altering the tension of the springs or by other The governor is also generally controllable by an ator pedal," the depression of which puts the gover-nporarily out of action, and allows the motor to de-s full power. The governor is particularly useful for ing the engine "racing" at such times as, owing to gencies of traffic or otherwise, the driver declutches, disconnects the motor from the driving gear. If no r be fitted, the clutch pedal should be coupled up to ottle, so that the action of withdrawing the clutch au-ally reduces the supply of gas to the engine.

Steering Wheel Control.

l cars, whether there is a governor or not, the driver



Clutch, Flywheel and Driving Shaft to Gear—
The Automatic Automobile.

The Automatic Automobile.

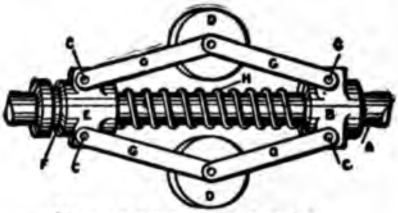
frequently controlled by small levers pivoted on the steering column just below the wheel. It is a convenience at first if the levers are impressed with names indicating their office, thus: "Throttle," "Gas," "Spark," and with directions for moving them, such as "Open," "Closed"; "Air," "Gas," and "Advance," "Retard," respectively. They should always be provided with finely-cut racks or other devices for retaining the levers or handles wherever they are set. It leads to needless worry and expense, for example, if the throttle lever is always working to the full open position, while the sparking lever persistently subsides to dead slow.

Governor—Owing to the fact that an internal combustion engine gives its greatest efficiency for fuel consumed, at a definite and constant speed, it is necessary that some form of regulator should be adopted which will act on some part of the mechanism in such a way as to reduce the speed should it get too high, or cause it to increase should it fall too low. For this purpose the centrifugal force set in a weight moving in a circle is utilized, and the appliance is known as "the centrifugal governor." There are many types of these, but the principle in all is the same.

Our illustration shows diagrammatically the principle on which all these governors work.

In this illustration A is the shaft which is driven from the engine by gearing, and generally forms part of the two-to-one shaft operating the valves. On it is a fixed collar, B, which rotates with it, and which has two projecting ears or lugs, as shown. A similar collar E, also having projecting lugs on it, is free to slide up and down on the spindle A, and has at its left hand end a groove F. These two collars, E and B, are connected together by the links G, G, G, G. It will be seen that these links also connect two weights D, D hung at their center. When the shaft A is revolved the centrifugal force, acting on the weights D, D tends to throw them outward. This action would cause the collar E to approach the collar B, but its movements in that direction are controlled by the helical spring H, which is in compression between the two

Vhen the centrifugal force balances the pressure of
, the collar E remains stationary on the shaft, but
crease of speed in the rotation of the shaft A, the
l force is increased, and, overcoming the resistance
ing H, the weights fly outward, drawing the collar
he shaft. By the movement of the collar E along
a motion can be given to a fork at the end of a
encircling groove F. This fork will give a motion
, which can be transmitted in any suitable manner
aratus which is used to either cut off the fuel sup-
rate the valves in such a manner as to decrease the



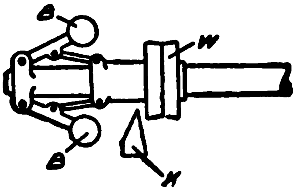
CENTRIFUGAL GOVERNOR

A, Shaft with which governor revolves.

as one might say) by burning out its coils with excess of current rather than stop.

The explosion engine keeps itself safe, but this, again, is a drawback in some ways. If a driver is not to be perpetually on the watch for overloading his engine at the slightest up grade it is clear that it must have a good margin of power when running on the level.

The maker must decide, therefore, that some predetermined small incline (let us say up to 1 in 30) shall be mastered by the car on its top gear, otherwise the unfortunate driver would be ceaselessly changing. It happens, however, that a grade of 1 in 30 takes nearly double the power required on the level at the same speed, so that on the level such an engine has always a large margin of superfluous strength, and is always inclined to "race." This racing is bad for the motor, which, therefore, is provided with a governor. On small cars, where the margin of power is not so large, racing is prevented by hand by (I.) retarding the ignition, (II.) partly closing the gas inlet, (III.) lifting the exhaust valve, (IV.) holding the exhaust valve intermittently down, and other devices. The governor on large cars generally effects either (II.), (III.) or (IV.) automatically. No. I is objectionable.



Hit-or-Miss Governor.

One device by which above a certain speed some movement essential to the drawing in of a charge of gas is prevented is the "hit-or-miss" governor—as in the figure.

The knife edge K may be made to rise and fall every time the exhaust valve is lifted. If, however, the speed is great enough to make the two fly balls B, B swing out they drag out with them the notch wheel W till it prevents the knife from descending, thus keeping the exhaust valve open.

articular speed the engine therefore fails to draw
, and therefore fails to fire till the speed falls again.
dom used on cars, but it will some day be used
se of its great fuel economy compared to the usual
closing the throttle by means of a pair of flybobs
e a rod actuating the throttle.

CHAPTER V.

CARBURETERS.

Carbureter—An apparatus used to transform the liquid fuel, generally gasolene, into a gas, and at the same time mix it with such a proportion of air as will make it combustible, so that it can be used in a gasolene engine in the same way as ordinary coal gas and air are used in a gas engine.

We may use two different methods to obtain a gas from the liquid fuel. We may draw air through or over the surface of the gasolene and thus vaporize it, or we may spray the gasolene into the air. In either case we have made the gasolene combine with the air so as to form an explosive gas.

The Surface Carbureter.

When we draw air through or over the surface of the gasolene we have what are known as surface carbureters, and these can be divided into three classes:—

1. The type of carbureter in which air is drawn over the surface of a body of liquid fuel and, evaporating, carries off with it a certain proportion of that liquid.
2. The type in which the capillary action of a wick is utilized, and the air is drawn through that portion of the wick above the level of the liquid and carries off with it the evaporated gas.
3. The type in which air is drawn through the liquid.

All these types are practically obsolete as far as automobile work is concerned. The surface type of carbureter is undoubtedly one of the most economical, but it fails through being incapable of rapid alteration of mixture, and on that account has been practically discarded for motor car work.

The Lanchester (English) surface carbureter consists of

rcular bundle of wicks threaded out at their lower
e ends being immersed in gasolene in a large inclos-
Warm air is drawn through the upper portion of
of wicks, and coming in contact with the gasolene
by capillary attraction, becomes charged with gaso-
r, the actual proportioning of the mixture being
l by means of an air cock admitting more or less
passage which conducts the mixture from the wicks
ine. The Ader type, also still in use in Europe, is
ller, but has materially the same action as that of
ester.

bbling or ebullition type of carbureter is another
nt which though at one time largely used, has now
ely abandoned for automobile work. The only case
this type is a carbureter for crude petroleum. In
e warm air is bubbled through oil heated to ebulli-
e exhaust from the engine, and so becomes charged
oleum vapor.

The Float-Feed Carbureter.

ay or "float feed" type of carbureter is now almost spray. In this finely divided or atomized condition the gasolene is readily evaporated and taken up with the inrushing air through the inlet pipe to the motor. Generally there are provisions made for admitting more or less air to the mixture after it comes from the jet, or spray chamber, this arrangement being necessary in order that correct proportions of gasolene to air may be approximately maintained.

The multiple jet type of carbureter is a development of the ordinary jet or spray pattern. With it there are a series of jets having various sizes of nozzle. The smallest is used at the lowest speed of the engine, while the increasing diameters are used either separately or in conjunction with the preceding jets as the speed of the engine is increased; it being evident that at a low speed, unless a very fine orifice is provided, the spraying effect will not be obtained, while with increasing speed and suction it becomes necessary to increase the area or orifice in order to get the requisite amount of gasolene through.

Originally all carbureters were made with a mixture supply and a source through which additional pure air might be drawn, and regulation was accomplished by opening or closing this supplementary air supply from the driver's seat, the accomplished results, of course, being in accordance with his skill.

In the early days of the 20th century, Krebs, a French engineer, invented what may be termed the first automatic carbureter in which the mixture was regulated automatically by the speed of the engine; flexibility being thus obtained to an extent hitherto undreamed of. This invention paved the way for, and inspired, a vast number of others of greater or less merit, but it also gave rise to one theory that has since been proved erroneous, namely, that in order to obtain the best results the engine should be fed by a carbureter which automatically keeps the proportion of air to gasolene always the same. It was on this principle that the majority of designers worked, and the result was that for a considerable

was a deadlock in carbureter design. Every one
w an erroneous condition and, where their efforts
this condition were the most successful, the actual
ained were the poorest. Experience since derived
hat in order to obtain maximum flexibility from
the mixture must be slightly richer in gas at low
ile it may have increased air proportion as the
lops. It is on this principle that most of the carbu-
d to modern machines now operate, although such
is very largely obtained automatically from the
ed.

ray carbureters it is necessary to provide means of

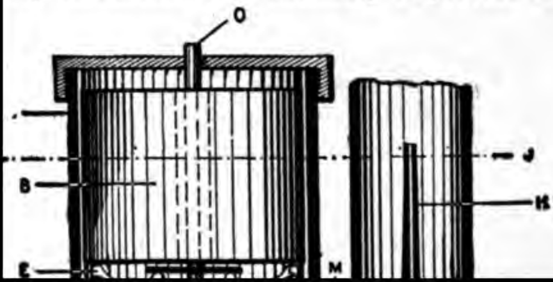


Fig. 1. A is the float chamber, supplied with gasolene through the inlet H. C is a needle valve, shutting off or opening the gasolene inlet. There is a collar around the needle valve, the weight of which keeps the latter normally closed. B is a float formed of a hollow chamber of light brass or other metal which floats in the gasolene. M is the outlet from the float chamber conducting the gasolene to the spray jet K in the spraying chamber L. The level of the gasolene normally stands at the height of the line J J, that is to say, just below the top of the spray nozzle K. When gasolene is sucked through the nozzle K by the engine the level of the gasolene in the float chamber is lowered, and the float descends. In doing so it comes in contact with the top ends of the levers E E pivoted at the points F F, and depresses them. The bottom ends of these levers then come in contact with the collar on the needle valve spindle, raising it and admitting more gasolene until the level is regained. It will be seen that the action takes place automatically, and the level of the gasolene in the float chamber and in the spray nozzle is retained at a constant point. This device is common to practically all spray carbureters, and whether the gasolene is supplied by gravity from a tank higher than the carbureter, or forced under air pressure from a tank at a lower level, does not in any way alter the working of the device.

The Longuemare Carbureter.

We may now deal with a few types of modern carbureters. One of the best known is the Longuemare, several models of which are made. Fig. 2 shows the automatic type; A is the float chamber containing the float B; F is the needle valve, normally closing the entrance for gasolene through the intake pipe H, I being the union for the pipe connecting it to the gasolene tank, and J being a drain cap. The two pivoted levers G G act, as we have already described, on the needle valve F, and keep the level of the liquid constant. The gasolene flows from the float chamber to the tube M inside the spray chamber N. The top of the tube M is cone-shaped, and a conical plug L is screwed down to seat on the end of it.

All round the edge of the plug L are grooves which form a number of radial spray jets, the suction of the engine drawing out the gasolene in fine sprays in the direction indicated by the arrows.

Around the vaporizing chamber N is an annular chamber V, which is supplied with hot air from the exhaust pipe through the union U. The air entrance is at the bottom, the air being sucked in through the opening X and rising around the spray tube M. It is kept close to the radial sprays of gasolene, by the circular baffle shown, which takes the form of a double inverted cone.

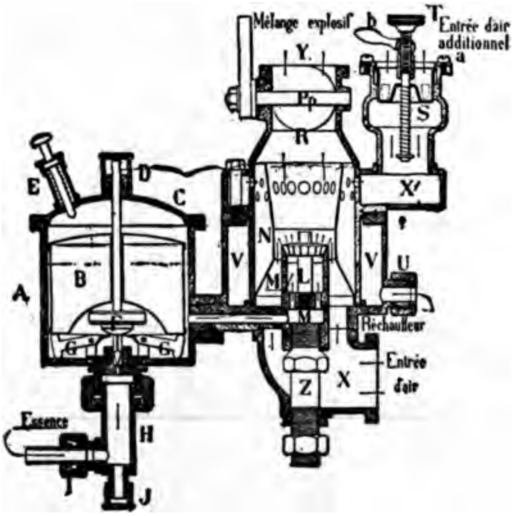


Fig. 2—The Longuemare Carbureter.

Around the top of the spray chamber is a second annular chamber X^1 in connection with the supplementary air inlet valve S. This valve S is kept normally closed by a light spring as shown, and the tension of this spring can be regulated by the milled thumb nut T and the lock nut b. When the engine speed, and consequently its suction, exceeds a determined limit it not only draws in the air and gasolene from the bottom of the spray chamber but also opens the valve S and draws in an additional supply of air which enters the spraying chamber by way of the holes shown in X^1 and mixes with the ascending gas charge, which passes out through the outlet Y, in which is situated a butterfly valve or throttle P.

It will be seen that if the throttle is closed partially the suction of the engine will not be enough to open the supplementary air valve, and a rich mixture will result. With the throttle open and the engine running fast, the supplementary air valve will come into operation and the most economical mixture will be obtained.

The Krebs Carbureter.

The next typical carbureter which we illustrate is the original automatic one previously mentioned, namely, the Krebs.

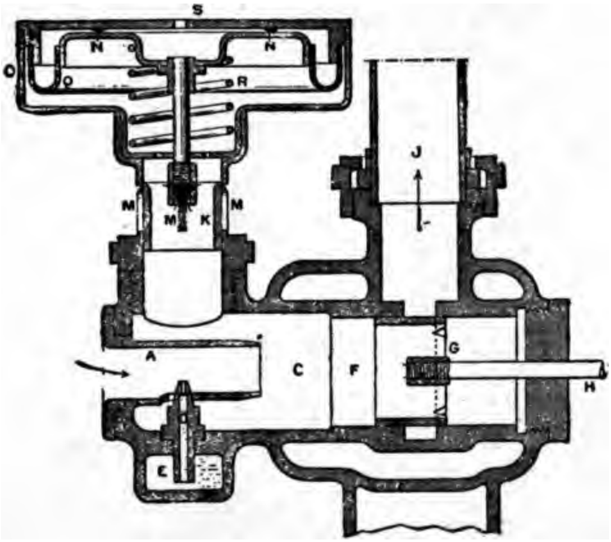


Fig. 3—The Krebs Automatic Carbureter.

In Fig. 3 E is the duct from the float chamber. D is the jet which protrudes through the wall of the air intake pipe A. J is the inlet pipe of the motor which is attached to the carbureter above the throttle chamber F, which takes the form of

headed cylinder in which a piston G slides, actuated
the rod H from the governor of the engine. The
-shaped notches seen in one edge of the piston are
as to give a very fine adjustment of throttling for
ne at low speeds. Leading into the chamber C is a
n which are cut additional air openings M M, the
area of these being controlled by means of the
, which is caused to slide up and down over the
M by the suction diaphragm N located in the suction
rked O. The diaphragm is simply a shaped metal
ich is attached to the piston K by means of a rod,
normally kept in such a position by means of a
arked R, that the piston K covers the ports M M,
in Fig. 3. The joint between the diaphragm plate
he walls of the suction head O is by means of an
ubber ring Q, which is free to rise and fall with the
m plate. In the illustration the throttle is shown
treme shut position, and the piston K fully covering
M M. Of course in such a position the engine
t run at all, but supposing the throttle piston G were

whereby the carburation is corrected in accordance with the speed of the engine may be derived in various ways. Thus in the Peugeot spraying carbureter the manufacturers alter their air inlet through the medium of a centrifugal governor. Others merely interconnect the air inlet and the throttle, this being a method employed by the Daimler company.

The Rover Carbureter.

One of the most ingenious, and at the same time the simplest, of these modifications, was that adopted by the Rover Company of England in their carbureter, which consists simply of a cock which has the jet located within its plug portion, so that as the throttle is closed the air is also shut down. The illustration is practically self-explanatory.

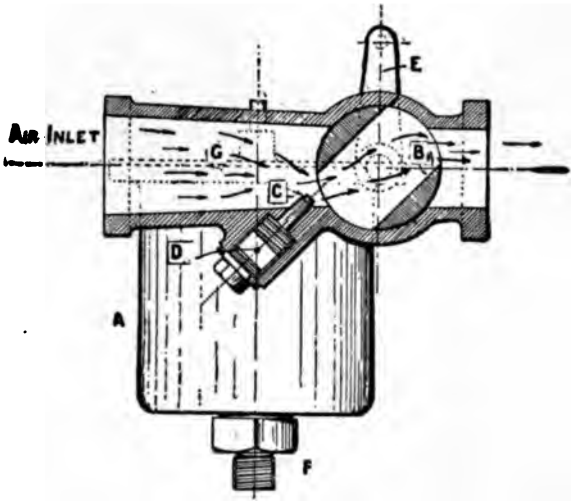


Fig. 4—The Rover Carbureter.

A is the float chamber into which the gasolene is introduced through the union joint F. The gasolene emerges from the float chamber through the hole D, and passes up through the spray nozzle C. This is set at an angle in the tapered air pipe G. The air enters from the left and is sucked through the air pipe by the suction of the engine in the direction of

ws. The gradually decreasing area of the air pipe
ne air to flow more rapidly and with an accelerated
nt as it nears the narrowest part of the air pipe, at
int it sweeps past the spray nozzle, which is inclined
irection of the air current. It will be seen that im-
y at the right of the air pipe is a rotating plug B
operated by the lever E. When this plug is turned
n the air has a clean run through, and, of course,
spray of gasolene through the nozzle C, the spray
with the air charge, and being carried on to the
n the form of combustible gas. If the plug is turned
position shown in the diagram the air passage through
ed and at the same time it has to pass down nearer
y nozzle. This has the effect of causing an approxi-
icher mixture than would be the case if the throttle
on the inlet pipe somewhere close to the engine,
position where its edge could not deflect the air
er the spray nozzle. The plug B, therefore, causes
onstant mixture to be obtained, whether the engine
ng with the throttle fully open or partially closed.

Multiple Jet Carbureters.

Multiple jet carbureters are often employed, particularly where a large range of flexibility is aimed at. In most of them there are from two to four jets which are unveiled to the incoming air in turn, and are either used one at a time (the commencement of a second jet causing a cessation of the first), or else in a series. In one of the simplest and most novel the spraying nozzle runs obliquely from the corner of the float chamber into the spraying chamber, and contains inside it a loose toothed rod, with some five or six serrations. In order to reach the spraying chamber the gasolene has to pass over the serrations cut in the rod, and these offer a certain amount of opposition to its passage. When the speed of the engine increases and the suction becomes great, the rush of the gasolene is interfered with to a greater degree than when the speed of the engine ~~is slow and the suction is~~ slight. In other words, when the gasolene dashes up against and into the angle of these serrations, the stream doubles back on itself, so to speak. Approximately correct mixture is therefore maintained at all engine speeds. Different sized toothed rods are supplied with each carbureter, so that the motorist can experiment for himself until he gets the best results.

Functions of the Carbureter.

In answer to the question of the novice, "What does the carbureter do?" it may be said broadly that the carbureter brings together a portion of liquid gasolene with about 8,400 times its volume of air, divides the liquid up into so fine a spray that the mixture of the air and liquid is made very intimate and complete, and provides means for keeping this mixture correctly proportioned under the varying working conditions of the engine.

Essential Parts.

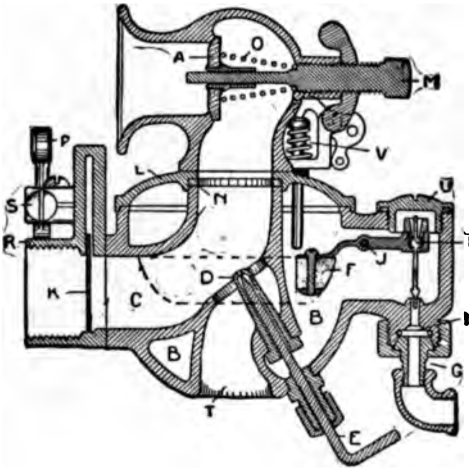
The essential parts of a typical float-feed carbureter may be stated as follows:

small pipe which supplies gasolene to the float

loat which, when raised by its buoyancy, inserts a
o, and thereby closes the small supply pipe.
ther small tube which leads gasolene away from
hamber to the spray nozzle.
spray nozzle or jet which squirts the gasolene into
e of the stream of air which is on its way to the

air duct along which the air (which is very often
s made to pass when the engine makes its suction
he parts of this air duct are called by different
follows: From the place where hot air enters a
er at the mouth of the duct up to the near neighbor-
he jet, it is perhaps most usually called simply the
pe and is often made of copper. All round about
self the shape of the duct generally changes. It is
spray chamber, and is usually made of cast brass.
his, from the spray chamber to the engine, it is
inlet, induction or mixture pipe, and is sometimes

that from 40 per cent. to 25 per cent. less air per stroke is taken in at high speeds with or without an automatic valve (at, say, 1,500 revolutions), than at low speeds (say, 150 revolutions per minute). This taking of less air per stroke is the chief and first reason why less gasolene per stroke must be



The Schebler Carbureter—Model E—Section.

A	**Compensating air valve**
B	**Float chamber**
C	**Mixing chamber**
D	**Spraying nozzle**
E	**Needle valve**
F	**Float**
G	**Reversible union**
H	**Float valve**
I	**Float connection**
J	**Float hinge**
K	**Throttle**
L	**Float chamber cover**
M	**Air valve adjusting screw**
N	**Cork gasket**
O	**Air valve spring**
P	**Throttle lever**
R	**Pipe connection**
S	**Throttle stop**
T	**Fixed air opening**
U	**Float valve cap**
V	**Flushing pin**

given if we wish to maintain what may be called the normal proportions of mixture. Notice here that we cannot hope to avoid the taking of less air even by making smoother and larger air passages and valves, since the chief impediment is not the friction of the air against the pipe walls, but the inertia and elasticity of the air which prevent our giving it

sary acceleration in the short time of a suction stroke
engine is going fast.
2.—Besides this chief reason, there are subsidiary
hy less than the normal flow of gasolene per stroke
at the highest engine speeds. Thus there is in-
ompression at high speeds, and this affects the mat-
most desirable mixture very appreciably. The vol-
ed in is about one-third less, but the compression
ten times faster, and this means a hotter compres-
therefore a higher compression, than if the same
f gas were compressed in the same engine more
To prove this, consider the two extreme cases of
mely, infinitely slow and infinitely fast. The dif-
f pressure can be calculated, and it is enormous.
gine of which the ratio of compression was only 3.63
bs. compression was calculated in the one case, and
the other, taking a supposed full charge of air in
.

ngine of the example had had the usual "five-to-one"
ion ratio, this would mean bad pre-ignition with a
ixture, and a poorer mixture automatically given

more gasolene than the average per stroke, and incidentally therefore for requiring an automatic valve or its equivalent, is based on a totally different consideration. At the limit of slowness with a normal mixture we fail, even with a retarded ignition, to keep the engine rotating, because of the evanescent character of the explosion pressure and the failure to ignite, or at least the incomplete inflammation of the charge, which would be much throttled down for slow turning, and therefore poorly compressed. But we find by experiment that a slightly more durable explosion pressure is secured, and much more certain ignition is obtained, when the mixture is rich in gasolene. We therefore decide to employ a rich mixture when running slowly and to put up with the drawbacks of a rich mixture, which are that we do not get complete combustion of the gasolene. We take the risk of a little smell and waste of fuel for the sake of having a "flexible engine."

There are many other ways of regulating the quality of mixture besides the use of the automatic or auxiliary air valve. It is largely a question for the engineer. The engine and the carbureter must be "tuned up" together to secure the best results.

One important practical condition amongst many has already been mentioned—it is known popularly as the condition which shows up the "flexibility" of the engine.

A "flexible" engine is one which continues doggedly to do a modicum of useful work when rotating quite slowly. The term "flexible" does not exactly fit the case, but it has become established. This property is assured not only by having the rich mixture at low speeds but also by increasing the number of cylinders, using mechanically operated inlet valves, increasing the size of the compression volume in relation to the piston displacement, etc. These engine matters again bear upon carbureter design, because they affect the rate at which the gas is called for and the manner and frequency of that call—proof again that engine and carbureter must be *fitted to* one another as carefully as a boot to a gouty

s quite interesting to summarize the number of evils
ugh sometimes due to other causes, may often be
adly adjusted carbureter. Sooted spark plugs, boil-
diator, eroded exhaust valves, loss of power, mis-
ste of gasolene, failure to pick up until some mo-
r any new position of the throttle has been adopted,
haust, "popping" behind the inlet valve, explosion
haust box, pre-ignition with resultant damage to
ts or connecting rods, failure of the engine to stop
spark has been interrupted, etc., etc.
of all this, it is small wonder that manufacturers
kept busy experimenting with innumerable meth-
suggestions for varying the quality of the mixture
manner remotely according to the conditions of its
nt.

A Cause of Heavy Gasolene Consumption.

urce of excessive gasolene consumption is the heat-
carbureter to a much higher degree than is neces-
that, independently of the suction by the motor a

and that is to cut off the hot air or water, as the case may be, from the heating chamber by means of a simple cock. It is only when running through a keen frosty air, or when the atmosphere is heavily charged with moisture, that the heating chamber is actually required, yet on many engines no provision is made for cutting off the source of heat, hence the increased gasolene consumption.

Letting in More Air.

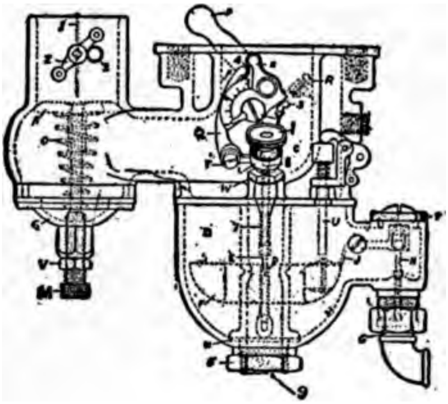
There is no doubt that many cars waste a lot of gasolene simply because the carbureters do not supply sufficient air. In this matter, car owners might well take an example from motor cyclists. Speaking generally, motor cyclists realize the advisability of using as weak a mixture as possible, and after a motor cyclist has passed his novitiate it is quite the usual thing to find that he has so altered or adjusted his carbureter that he can always command an adequate supply of air, as very few cycles are turned out with provision for a full supply. It is not merely a question of economy of gasolene, though that is quite an item, but in many cases more power can be obtained from the engine, and it keeps much cleaner, while the valves keep cooler and the smell from the exhaust is much less if the weakest possible mixture is used. An extra air inlet is therefore a good thing and there are many ways of increasing the air supply.

Water in Air Pipe.

The air supply pipe to carbureters of most cars is arranged so that the pipe can be open to the air, or made to take its air from round the exhaust when the temperature of the outer air is so low that good running cannot be obtained unless the air be heated. On many cars the air pipe is high up and well out of the way, but there are a number which have the pipes so arranged that when the car is washed, some of the water may splash into it at the cold air slot. We have come across instances in which this has occurred, so that the water has been sucked into the carbureter; then if the engine does not run well, it has been assumed that there r in the gasolene, though, as a matter of fact, any ntity which might enter through the induction pipe lly do no harm. At the same time, when one sees pping from the carbureter, it is only natural to the first glance that it is caused by water in the However, we give the hint for what it is worth; dea is once obtained that there is water in the gaso- of trouble will be taken for nothing. There is also amount of condensation in the induction pipe, and noisture may be noticed in it from this cause.

Flooding Carbureters.

persistent flooding of carbureters occurs, it is gen- to one of two things: Failure of the needle valve operly, which can, of course, be overcome by grind- valve, or to a punctured float, which allows a small of gasolene to enter, and thus upset the balance and gasolene level to rise higher than it should do, and ntly to flood. This can be easily discovered by he float, when the liquid can be heard inside. To nole and get the gasolene out is somewhat difficult, With carbureters of the Longuemare type, with a weighted needle, flooding is sometimes due to a third cause. The weight occasionally bears on the seating, and does not allow the needle to seat properly. The result is that flooding occurs either continuously or intermittently when the motor is running, as then the vibration shakes the needle from its seat.



The Schebler Carbureter—Model F—Section.

A	Compensating air valve	S	Pivot screw
B	Float chamber	T	Float valve cap
C	Mixing chamber	U	Flushing pin
D	Spraying nozzle	V	Lock nut
E	Needle valve	W	Needle valve hex connection
F	Float	X	Spring cam casting
G	Reversible union	Y	Eccentric high speed adjustment
H	Float valve	Z	Air valve shutter lever
I	Needle valve adjusting screw	1	Air valve butter-fly disk
J	Float lever	2	Spring
K	Throttle	3	Lock screw
L	Needle valve retainer	4	Cam spring
M	Air valve adjusting screw	5	Lock nut for bowl
N	Cork gasket	6	Air valve cap
O	Air valve spring	7	Needle valve retaining spring
P	Throttle lever	8	Needle valve spring
Q	Needle valve lift lever	9	Constant air opening
R	Throttle stop		

Warming the Carbureter.

A kink applied very successfully for starting the engine when the atmosphere is chilly is simply to fill an ordinary india-rubber hot-water bottle and apply it as far round the carbureter as possible, leaving it there for a sufficient period

the carbureter itself to draw some heat and thus
orization. Another method is to wrap around the
some absorbent material, such as large size lamp
ch can be carried for the purpose, and to pour over
vater, repeated applications of which will raise the
re of the carbureter even higher than will be ob-
the usual heating by a branch from the exhaust.

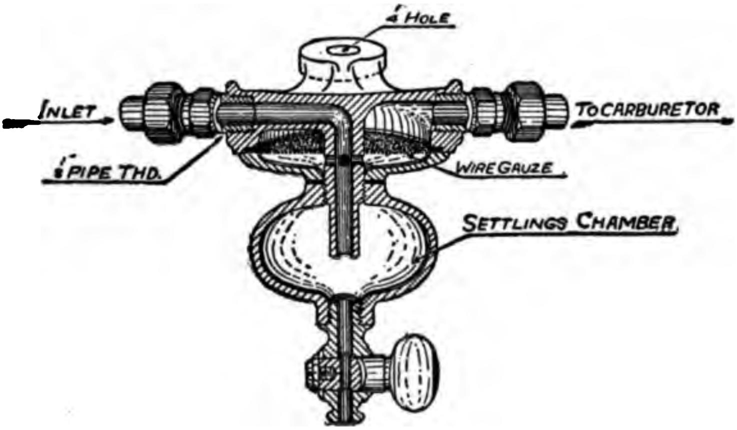
The Freezing of Carbureters.

a snap of frost," writes an enthusiastic automo-
had an experience with one of our cars which
a warning to others. While the cooling water cir-
ystem was in a sufficiently warm place to prevent
g up, yet it did not protect the carbureter from
of the frost. This particular carbureter has a hot
ket around the mixing chamber, which is in close
to the float feed chamber. A single cock is pro-
revent the water circulating round the jacket when
is not required, but it was impossible to drain the
n the jacket. The low position of the carbureter,
wer temperature occasioned by the near presence of

plenty do not. It is simply a matter of holding the float down or up, according to which way the gasolene is admitted, so that the full head of gasolene in the tank may come through to the jet. In nine cases out of ten it will free it—possibly only temporarily, but still enough to enable one to get along and to postpone the taking down of the jet till one gets home. When once the engine has been got going again one can keep a careful ear upon its running, and directly it shows signs of flagging, race it a bit, and race it with the extra air inlet (if such is provided) closed. This puts so strong a suction on the jet that it will often remove the obstruction, and that without stopping the car.

Choked Carbureters.

One of the most exasperating of minor troubles which can fall to the lot of the motorist is to have a partially choked gasolene jet in the carbureter. If the jet were wholly blocked up and the engine could not be run at all, one would naturally go to the carbureter (if not at once, directly after testing the ignition), and the cause of the trouble would be revealed. On the other hand, when there are particles of foreign matter floating about, they will keep more or less clear of the jet,



The Schebler Fuel Strainer—Cross Section.

are never far away. You flood the carbureter and the engine, which runs merrily for a few revolutions, hokes, and stops. What has happened? Those free ıst which were merely agitated by the action of flood- arbureter have by the constant suck exerted by the een drawn up into the jet and effectually blocked it. ine being stopped, the bits fall away from the jet d so the process of numberless startings up of the performed. Now, if the ignition be found in order, gasolene feed to the carbureter be clear, it is nearly dvisable to proceed to the jet and clear it out straight Vhile the jet is out, run some gasolene through the e to wash away any particles which may be left The jet being clear, it may be replaced and flooded, to ascertain that all is perfectly in order.

Attention to Automatic Carbureters.

atic carbureters, like many other good things, re- ping thoroughly up to the mark, otherwise they are come a source of trouble. A great many of the auto- buretera now in use have a sliding plunger or piston bureter, nor until the gasolene vapor is thoroughly removed must a lighted match be thrown on the floor, otherwise a fire is certain to ensue.

Another frequent cause of trouble with automatic carbureters is that due to the spring losing its tension or in other ways getting out of adjustment. There is usually a small nut or pair of nuts fitted, which can be screwed up or down to alter the tension or pressure on the piston controlling spring, and sometimes such nuts are rather likely to shake loose and alter their position relative to the stem on which they are screwed, thus altering the spring tension. These should be examined from time to time to assure the user that they are in the correct position. When the spring becomes too weak, either a new spring must be fitted, or, as a temporary measure, the old spring can be removed and carefully stretched and then replaced, the adjustment being made by means of the nuts, as before mentioned.

Air Inlet Gauzes.

Assuming the gauze to take up three-quarters of the air inlet—which is usually the case—the area of the gauze should be made about four times as large as the actual air inlet.

This is provided for by supplying a funnel over the mouth of which the gauze is to be fixed. As an alternative, if the funnel cannot be fitted, the gauze should be made into a cone and slipped inside the pipe, as in this way the area of the gauze is made sufficiently large to allow the right quantity of air to pass through it.

Gauzes fitted to the air intake of any kind of carbureter should be frequently cleaned. Otherwise they rapidly choke up with oil and dust, the result being that insufficient air passes to the carbureter, which means that the suction on the jet is increased and more gasolene taken to the engine than should be the case, resulting in heavy consumption, boiling water, dirty engine, overheating, and loss of power.

It is often remarked that unless a gauze is fitted the carbureter will choke up. In such a case the fact is overlooked

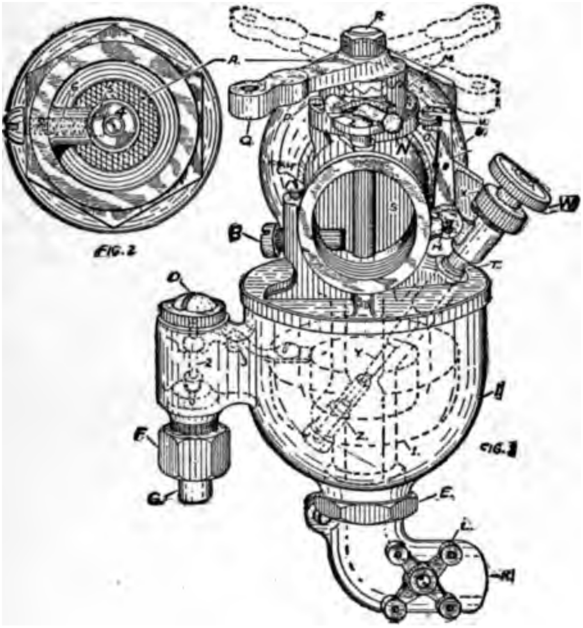
kage in a carbureter is due to chokage of the gaso-
age, and not to the air passages, and that dust getting
carbureter by way of the air intake cannot get into
r gasolene passage. As a rule the only damage that
do is to get into the engine and pass out through
ust valve. While in the engine it can do little harm,
deposit may be formed on the piston head by it. In
it appeared to be carbon, in consequence of the bad
of the lubricating oil. An analysis of the deposit,
proved that it was caused almost wholly by dust-
r which was drawn in through the air intake, which
protected by gauze.

usly, the best thing to do is to fit a large gauze,
detachable, and to keep it clean.

Gauze in the Induction Pipe.

time to time many experiments have been made with
Occasionally a wire gauze disk is put in the induc-
e, and gauze has been tried in the carbureter. The
hat the mixture shall be more thoroughly atomized
ng through the fine meshes of the gauze. It may

is also a sort of wick effect, as the three or four thicknesses of gauze make a pad immediately above the jet, which is always saturated with gasolene, and seems to afford a small reserve, which results in a better pick-up after slowing on the



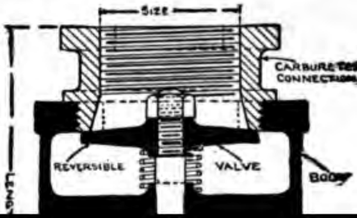
The Schebler Carbureter—Model H—Section.

A Compensating air valve complete (4 pcs.)
B Low speed adjusting screw
C Low speed lockscrew
D Float valve cap
E Float chamber lock nut
F Reversible union
G Reversible union nipple
H Lift lever shaft retainer
I Float chamber
J Mixing chamber
K Constant air opening connection
L Butterfly valve starting lever
M Spring cam casting
N Eccentric high speed adjustment
O Cam spring
P Throttle stop
Q Adjus'ble throttle lever casting
R Throttle valve stem
S Throttle valve butterfly disk
T Needle valve retainer
U Needle valve lift lever
V Cam roller
W Needle valve adjusting screw
X Needle valve adjustment retainer
Y Needle valve
1 Float
2 Float valve
3 Float valve lever
4 Air valve adjusting screw
5 Leather friction disk
6 Friction spring

It is obvious that the gauze must have a wire-effect, and thereby put a certain amount of negative
on the engine, but this negative effect is more than
by the superior atomization, so that the maximum
d speed of the engine is not reduced in any way,
dvantages of smoother running at low speeds and a
ick-up are gained.

The Breeze Carbureter.

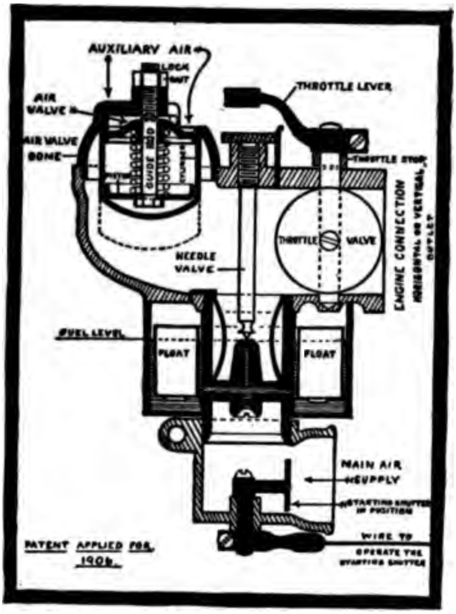
reeze carbureter is a good example of the modern
r, and is therefore fully illustrated herewith. The
urers claim that this carbureter is equally adaptable
ines and that, when adjustments are once properly



3. Non-fluttering auxiliary air valve maintains an even addition of air to the mixture at high speeds.

4. Central draught for main air and gasolene spray prevents changing of fuel level on grades. The gasolene is always there.

5. Peculiar construction of the needle valve causes the breaking up of the fuel into the smallest particles possible, giving at the same time economy and power.



The Breeze Carbureter, Showing Main Air Supply and Strangling Tubes.

6. Choice of vertical or horizontal, or male or female connection to engine.

7. Carbureter easily detachable from flange of engine pipe connection.

8. Spun brass float, obviating all need of adjusting fuel level, which is a frequent trouble with a cork float.

9. Interchangeable main air tubes giving a wide range of

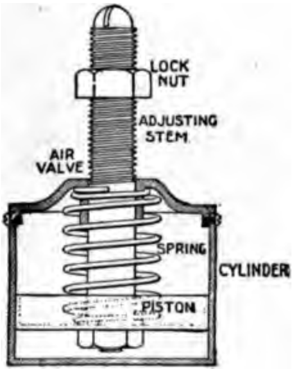
supply and still maintaining the correct cone-shaped ge.

nple and easily detached hot air attachment.

ɔle—The Breeze carbureter consists of a fuel chamber with a float feed device to maintain the fuel level t a point just below the spray nozzle, which is con- a cross tube to the fuel chamber; when air is sucked he conical-shaped main air tube by the engine, a pro- f gasolene is drawn up into the engine with it. This n is determined by the adjustment of the needle valve. uction increases when the throttle is opened or the uns faster, the proportion of gasolene taken up is han it should be, so the auxiliary air valve is pro- d arranged to open against a spring and admit pure rding to the increased suction of the engine. By djustment of this valve spring, it is claimed, the car- can be made to furnish a uniform mixture to any A valve or throttle is provided to govern the amount gas delivered to the engine.

neness of the mixture of gasolene and air determines distance which the spring tension permits. This adjustment properly made, the suction of the engine regulates the mixture automatically by pulling the valve open to the proper distance.

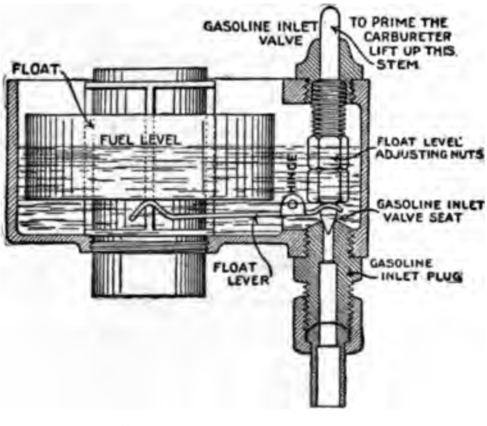
To adjust the valve, loosen the air valve adjusting lock nut, turn the slotted stem to the left to stiffen the spring and decrease the air, to the right to weaken it and give more air. Be careful in weakening the spring and giving more air not to weaken it so much that the valve does not seat. Air must not get in on low speeds or starting will be almost impossible. Lock the adjustment securely.



The Breeze Carbureter—Auxiliary Air Valve.

This device is simple and needs no attention unless both oil and sand get on it at the same time, in which case it will stick and must be cleaned out. Leave all parts dry. Do not oil it. If this happens it would be advisable, for the good of the engine, to protect the carbureter by an apron. The amount of sand required to spoil the working of the air valve would be very bad for the engine if allowed to get to it. No trouble is experienced with the valve under the hood of a touring car. When a carbureter is used where water or dirt are thrown on it, the manufacturers furnish a gauze cage to cover and protect it.

Float Feed Mechanism—When the fuel is at the proper level the gasolene inlet valve is held down to its seat by its own weight and the spring closes the supply, the float being clear of the float lever. As soon as the level drops the float drops with it, and resting its weight on the long end of the float lever pushes it down and lifts the short end which lifts the gasolene inlet valve and admits more fuel till the float rises clear of the lever again. To raise the fuel level adjust the nuts on the gasolene inlet valve nearer the point of the valve; to lower it, set them further away. Lock them tight after the adjustment is made. The distance from the bottom edge of the adjusting nut to the point of the gasolene inlet valve averages about 5-16 of an inch on a properly adjusted carbureter. **Don't** change the tension of the spring. The fuel level must be properly adjusted on any float feed carbureter. The correct point is usually about 1-16 inch below the tip of the spray nozzle. For an engine with short inlet pipe of large diameter the level may be set a little lower. Keep the level as low as possible. A high fuel level wastes fuel and causes an engine to heat up.


GASOLINE INLET VALVE
TO PRIME THE CARBURETER LIFT UP THIS STEM
FLOAT
FUEL LEVEL
HINGE
FLOAT LEVEL ADJUSTING NUTS
GASOLINE INLET VALVE SEAT
FLOAT LEVER
GASOLINE INLET PLUG

The Breeze Carbureter—Float Feed Mechanism.

Adjustment of the Breeze Carbureter—Adjustments can always be best made with the muffler cut out or better still the exhaust pipes taken off so that the exhaust from each cylinder may be observed. If the ignition is right and the compression and valve setting the same on all cylinders the exhausts should all be the same color. The blue flame exhaust is not the best for power, the mixture is too rich. The purple flame is the correct color. A yellow color shows too weak a mixture; black smoke, too much fuel. Too much oil makes the color red.

From three-quarters of a turn to a turn and a quarter is the usual opening of the needle valve required. Screwed all the way down it is closed. To open it turn backward. The correct position can only be determined by experiment. With the throttle and spark stationary, the correct position for the needle valve is that at which the engine runs fastest.

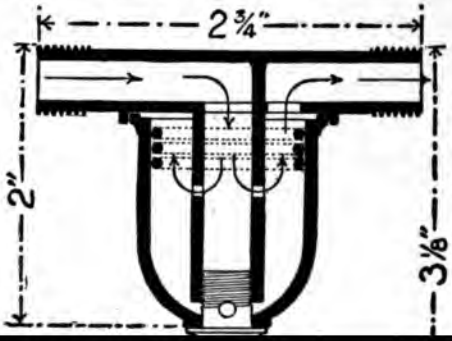
Gauze Cage for Exposed Carbureters.

Set the needle valve first for low speeds with the throttle nearly closed and the spark on center. Then advance the spark and open the throttle and adjust for high speeds by tightening or loosening the tension of the auxiliary air valve spring.

Backfiring is caused by too weak an air-valve spring, dirt in the carbureter, or an insufficient flow to the carbureter. If the auxiliary air valve spring has to be weak, a small strangling tube may be used around the spray nozzle and a large one where the auxiliary air valve spring has to be very strong. A particularly strong spring has to be used with engines of the valve-in-the-head and "T" head types.

Carbureter Troubles.

lowing remarks, for which we are indebted to "Car-
nd Engine Troubles," published by the Breeze Car-
ompany, apply to almost all float feed carbureters.
ve springs shorten slightly after long use, and ad-
is provided to take up the tension. Imported steel
springs, copper plated to prevent rust, stand up
an the cheap brass wire frequently used.
tting into the spray nozzle causes backfiring in the



the carbureter, sticking float lever or fuel valve, and very often by a nearly broken battery wire, dirty commutator or sticking coil trembler. Speeding up and slowing down under load are generally caused by too small a fuel pipe, insufficient head to the fuel, or dirt or water.

Overheating of the engine may be caused by many things, as insufficient water circulation, improper timing or insufficient lift to exhaust valves. Either too weak or too rich a mixture burns slowly and gives up a larger proportion of heat to the cylinder head and wall than a perfect mixture does. A poor spray overheats, so does poor oil.

Often when a new carbureter is fitted to a car that has been used the complaint is made that as soon as the throttle is opened the engine pounds and knocks and that the symptoms are worse than before. Very likely. The new carbureter probably gives more gas and power than the old one, and of course when combustion chambers and piston heads are carbonized from poor oil or bad mixture, the more gas you put in the cylinder the worse the knock. Take off the cylinder heads and soak them over night in kerosene, clean them thoroughly, and piston heads too, and don't neglect the valve passages. It is not so much the even deposit as the little lumps that stick up that cause the trouble.

Commutators or unevenly timed tremblers on coils sometimes cause trouble. The explosions must take place in each cylinder when the piston is in the same position. If any cylinder is timed too early there will be loss of power, knocking, overheating and possibly a broken crankshaft and always a quicker wearing out of wrist pin and crank pin bearings. A wabbly commutator makes the same trouble.

Missing in one cylinder may be caused by that cylinder having a leak around the valve or valve cage seats, by the inlet valve opening too much and not closing as quickly as the others, or by a valve not seating at all; or, by that cylinder being carbonized. These things cause the engine to take a different mixture. If the cylinders are right the same carbureter adjustment will suit all.

ng—Suppose when you turn on the gasolene or sto
ine there is a persistent dropping of gasolene fro
m of the carbureter. It must be stopped, fuel is bein
nd the mixture spoiled on low speeds.

start in to change the fuel level till you are absolutel
wrong. Flooding when caused by dirt under the fue
often be stopped by lifting the fuel inlet valve an
he dirt flush through. If this does not stop it th
ost likely too high.

readjusting the float level you might take off th
take out the float and shake it and listen for liqui
leak, though very rare, is possible, and will permi
to get inside and lessen the float's buoyancy. Writ
r a new one and then return the leaky one for repairs
rary repair can often be effected by drying out th
and painting a little shellac over the leak. Don'
loose solder in the float for gasolene.

tested these points if the trouble is not there, th
is too high and must be adjusted. Shut off the fue
e you put away a car. It is safest, because there i
feed mechanism that can always be trusted abso

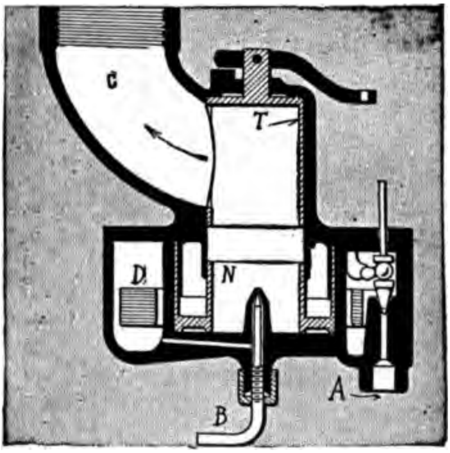
Flooding seldom means readjustment of float feed mechanism. Usually there is dirt under the gasolene valve seat or, very rarely, a leaky float.

Don't forget that automatic inlet valves must have a very short lift, and when the engine has more than one cylinder, the springs in these valves must be of an even tension. If these springs are weak or have too much lift, part of the gas will be blown backwards through the carbureter in the compression stroke.

Don't monkey with any carbureter till you have read the maker's book. You may know more about it than he, but you might as well get his ideas on the subject.

The Duplex Carbureter.

The Duplex carbureter, illustrated herewith, deserves attention because of its simplicity, freedom from springs of any nature, and compactness of design. Its only adjustment is with the gasolene needle valve B, which can be accomplished from the under side of the carbureter. In design the Duplex carbureter is conventional with its gasolene intake A, regulated by a needle valve, controlled by the concentric float D.



Section of Duplex Carbureter

revolving vertical cylinder throttle and C the pas-
to the motor. This carbureter is without any auxil-
ntake and the only air intake is regulated by a solid
which is claimed not to impose any drag whatever on
e. The action of this sleeve is governed by vacuum
fic gravity. The sleeve is protected by an air cushion
the degree of vacuum depends entirely upon the ac-
ne engine. The rise and fall of this sleeve N is en-
omatic. A glance at the carbureter will show that
g arrangements are provided for, the maker claiming
reter to be capable of quick and easy action, which
starting in cold weather. The throttle lever seen on
s attached by a binding screw which permits of ad-
to conveniently attach the lead to the steering wheel
ection, thereby eliminating complicated connections.
pipe C is of such design as to permit of the carburet-
used on vertical or horizontal motor.—Motor Age.

The Locomobile Carbureter.

ocomobile carbureter is shown here in diagram, with
y fuel feed system. It is described in the following

impurities cannot pass up into the float chamber. This is an extremely interesting feature of the Locomobile carbureter and will appeal to anyone. The settling chamber and the wire gauze can be removed when desired and cleaned if necessary.

"The Locomobile carbureter is of exclusive design and manufacture and is of the simplest possible character, operating in a reliable and satisfactory manner, with practically no attention. The float is of spun copper and is carefully adjusted, the adjustment being marked on the top of the carbureter, so that in case it is necessary to readjust it, it can be done without returning the apparatus to the factory.

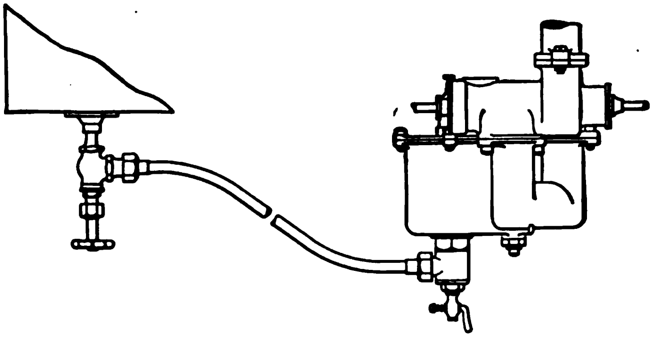


Diagram of Locomobile Carbureter and Gravity Fuel Feed.

"The spray nozzle, or atomizer nozzle, consists of a hollow tube, pointed at the upper end; it screws into the bottom of the carbureter casting until the lower part comes up against a shoulder. Thus the nozzle may be removed instantly and cleaned, and when put back the adjustment is not disturbed.

"The throttle is of the balanced piston type, desirable because the suction from the pistons of the motor does not cause it to bind against the walls of the throttle chamber and cause friction.

"The automatic air valve is used, of course, to supply the additional air as the throttle is opened and more gas is fed to the motor. The Locomobile valve consists of a hollow, cone-shaped spring, the coils of which separate as the motor speeds up, thus feeding more air to the mixture and keeping m in quality. This forms an extremely simple and ırrangement.

mixing chamber of the carbureter is supplied with es, one admitting hot air drawn from around the and one for cold air; thus a full supply of hot air fed to the mixing chamber, or any desired mixture d cold air which will give the best results for conditions hey may exist at the time. The adjustment as made ctory is correct for ordinary atmospheric conditions ld rarely be altered."

CARBURETER ADJUSTMENTS.

The Holley Carbureter.

illustration of the Holley carbureter the adjustable needle is shown (L). The air enters at A and passes

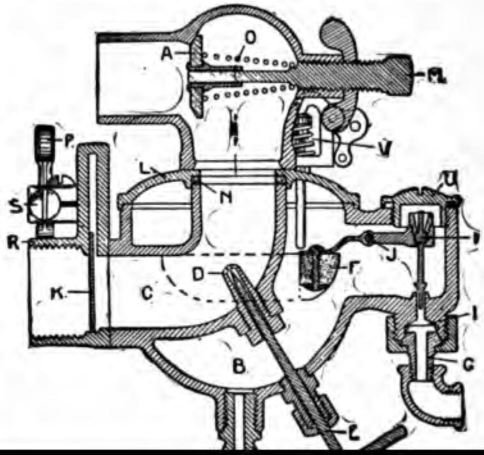
highest speeds the puddle is wiped out and an ordinary spray takes its place. An overflow device prevents flooding.

In operation the gasolene needle is adjusted to a point where the motor runs best, with throttle wide open and spark about center. Next close the throttle to where the motor runs slow enough to suit. If the motor will not run slow, it indicates lack of gasolene because of too low level. If motor runs slow enough with throttle partly closed, but misses upon opening throttle, it indicates too high a gasolene level. To change the level remove the gasolene inlet needle guide cap T and take out the gasolene inlet needle. Hold the weight M by its flat sides (so as not to mar it and cause it to stick) and loosen the taper locknut O. Then by screwing the needle into the weight M the gasolene level is raised in the float chamber; by unscrewing these parts, the level is lowered. One turn of the needle L in the weight M changes the gasolene level about 3/32 inch; one half turn about half, etc. When level is where desired tighten locknut O. Normal level should show puddle about 3/32 inch deep when motor is not running. Conditions may demand this to be altered slightly. R is a sediment plug and has nothing to do with adjustment.

The Schebler Carbureter.

In the Schebler carbureter, of which we illustrate several models, when the motor is running at its minimum speed, the air is drawn through an aperture of fixed dimensions. As the speed is increased, and consequently the flow of gasolene becomes greater, more air is needed and this additional supply is furnished by the compensating air valve A (see illustration of Schebler Model D), which opens more and more as the speed of the engine increases. The compensating air valve, when once adjusted, admits a regulated supply of air in accordance with the degree of vacuum produced by the piston of the motor. In adjusting, the needle valve E should be first closed, and then opened about from five-eighths to three-quarters of a turn. Retard the spark, open the throttle P about one-fourth, so as to equalize the fixed air open-

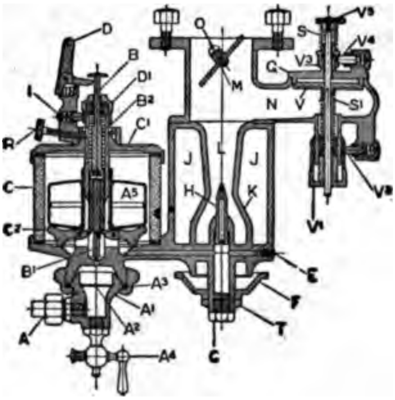
w the compensating air valve A. Start the motor
st the needle valve E until the motor runs smoothly
out back firing or missing. Now open the throttle
keeping the spark retarded, and by turning the air
justing screw M increase or weaken the tension on the



Schebler carbureters are made of brass, but aluminum is furnished on special orders. The bowl design combines compactness with practicability, serving for reservoir as well as having the float chamber embodied therein. The float is made of cork, heavily shellaced and hinged as shown in the sectional view, letter J. The size of the gasolene valve is much larger than ordinarily used. Gasolene is supplied through a reversible union which permits the feed pipe to run in any direction desired.

The Stromberg Carbureters.

Many well-known machines are fitted with the Stromberg type carbureters, of which we illustrate two examples in section, namely Types A and B.



Stromberg Carbureter—Type A—Section.

The following are the methods of adjusting these carbureters:

How to Adjust Stromberg Type A.—After the carbureter is installed turn on the gasolene, and note if the level of the gasolene in the float chamber is opposite the mark or line cut on the outside of water jacket opposite float chamber. By turning the adjusting nut D-1 up or down you can raise or lower the gasolene level so that it will be opposite the o this before starting the engine. Next see that the seats lightly by tapping the nut V-5 lightly with the r. If it does not seat, turn up adjusting lock V-1, or ght, turn down V-1. See that adjusting locknut V-3 l down as low as possible. Next prime the motor g the needle valve B until float chamber is filled. l notice that gasolene drops into the adjustable air This cup should be adjusted in this manner: Turn r cup F until it is tight, then turn it down one or two ossibly three, according to the motor. On the av- otor this will admit the proper amount of air which the gasolene supply. If you are getting too much , turn the cup up, if too little, turn it down.

start the motor and adjust the low speed adjusting with both the throttle and the spark retarded. The -1 is used to seat the valve V, and if the mixture is and engine back fires, turn up nut V-1 until the ns smoothly. Next advance the spark and open the gradually until it is wide open, and if the motor s, turn up the high speed adjusting nut V-3 one notch e until the motor runs smoothly without back firing.

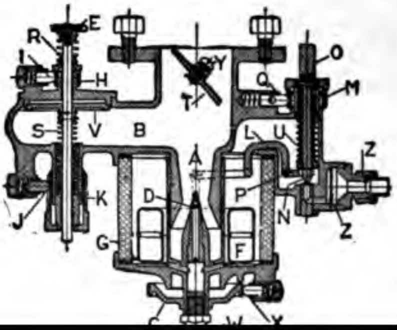
The motor uses just enough gasolene to keep it going on low speed, and as it increases in speed it takes automatically the quantity of gasolene which is necessary. The suction created by the motor draws air in through the fixed air opening between the adjustable air cup F and the bottom of the water jacket passes up through the mixing chamber L past the spraying nozzle H and in passing sucks the gasolene out of the nozzle in a canopy-shaped spray. This mixture is then joined by the air coming through the valve V, which creates a perfect mixture. The more air that comes in through the adjustable air cup and the less through the valve the richer the mixture will be and vice versa, so do not have your spring S-1 too tight.

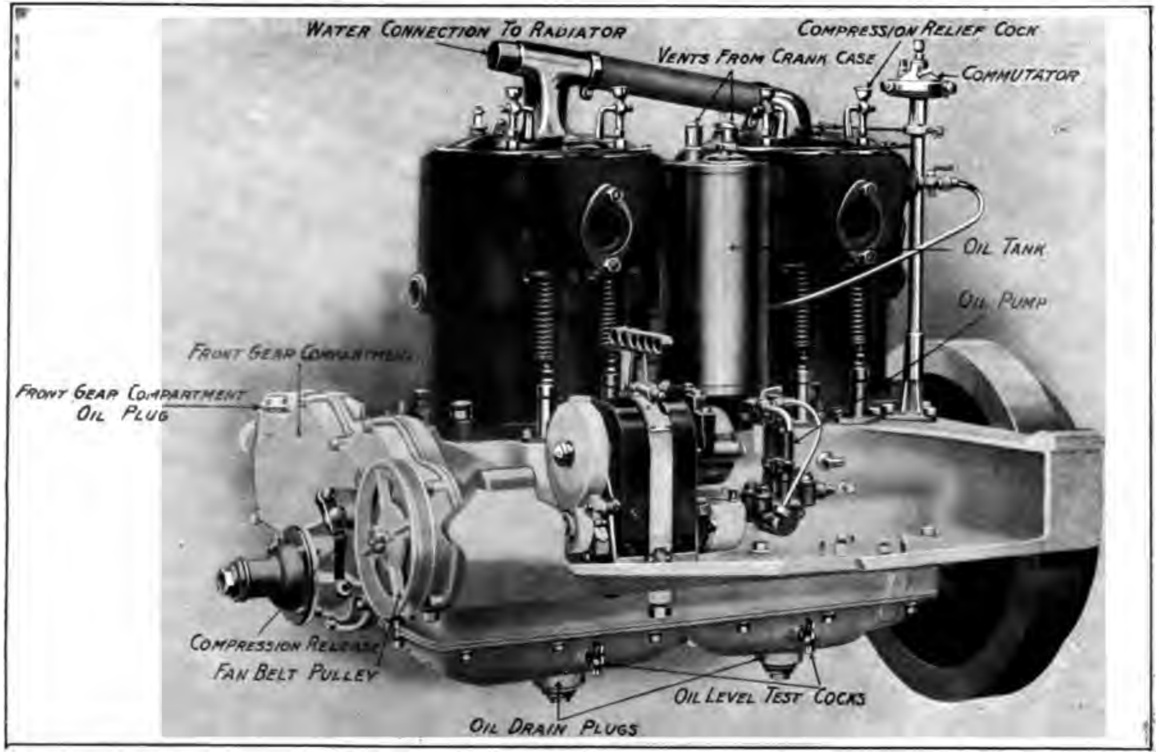
How to Find Proper Nozzle Size—If after you have adjusted the auxiliary air valve according to instructions, the mixture is still too rich, adjust valve V until it is off its seat, then adjust locknut V-3 down as far as it will go, and if the mixture is still too rich, it is conclusive proof that the nozzle in the carbureter is too large. If the motor misses on high speed on normal adjustments, tighten up on valve V by turning up the nut V-3 and nut V-1. If these springs are then too tight to get proper mixture, put in a smaller nozzle. To change the nozzle H, remove the plug G, then take out nozzle with an ordinary screwdriver.

How to Adjust Stromberg Type B—Type B differs from Type A in being made without the water jacket and is concentric, having the float chamber built around the mixing chamber.

After the carbureter is installed turn on the gasolene, and note if the level of the gasolene in the float chamber is 15-16 inch from the rim on the bottom which holds the glass. By turning the adjusting nut M up or down you can raise or lower the gasolene level. See that the level is right before starting the engine. Next see that valve V seats lightly by tapping the nut E lightly with the forefinger. If it does not seat turn up adjusting nut K, or if too tight, turn down K. See that adjusting locknut H is turned down as low as pos-

Next prime the motor by lifting needle valve O until
mber is filled. You will notice that gasolene drops into
stable air cup C. This cup should be adjusted in this
: Turn up the air cup C until it is tight, then turn
two full turns. On the average motor this will ad-
proper amount of air which regulates the gasolene
If you are getting too much gasolene, turn the cup
o little, turn it down. Next start the motor and ad-
low-speed adjusting nut K with both the throttle
spark retarded. The spring S is used to seat the





The Packard Motor.

justing nut, to stop motor back firing you will have to turn up nut K one or two notches, but after doing this be sure to see that the motor runs smoothly on closed throttle.

The motor uses just enough gasolene to keep it going on low speed, and as it increases in speed it takes automatically the quantity of gasolene which is necessary. The suction created by the motor draws air in through the fixed air opening between the adjustable air cup C, and the bottom of the gasolene chamber, passes up through the mixing chamber A past the spraying nozzle D, and in passing sucks the gasolene out of the nozzle in a canopy-shaped spray. This mixture is then joined by the air coming through the valve V, which produces a perfect mixture. The more air that comes in through the adjustable air cup, and the less through the valve the richer the mixture will be and vice versa, so do not have your spring S too tight. To change the nozzle D, remove the drain cock, then take out nozzle with screwdriver.

Carbureter, Alcohol—Carbureters for the use of denatured alcohol instead of gasolene in internal combustion engines are now successfully in operation. Experiments have also been made in the use of alcohol with acetylene. In this case the alcohol mixture is passed through a wire gauze containing calcium carbide and the water contained in the mixture acts upon the carbide and produces acetylene gas. Another type of alchohol carbureter is used with alcohol and gasolene, the engine being started with gasolene and running with alcohol as soon as the carbureter is sufficiently heated. Heat is invariably required for the complete vaporization of alcohol.

CHAPTER VI.

TRANSMISSION MECHANISM.

ission—The term "transmission" applies strictly to tional surface is secured by means of a wide strip of leather riveted on the face of the clutch, and flat springs are placed at intervals underneath the leather, so that when the clutch is engaged with the flywheel, the car starts smoothly and gradually. The pressure of two strong coil springs causes the clutch to be normally engaged with the flywheel and the pressure of these springs is overcome by a pedal operated by the left foot.

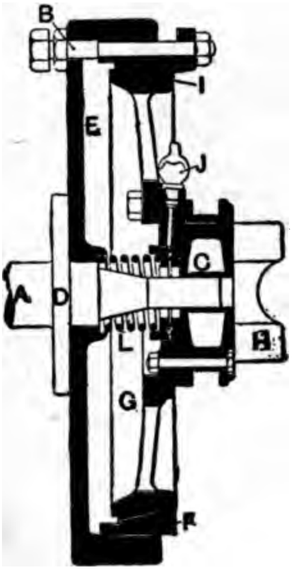


FIG. A.—SECTION OF INTERNAL CLUTCH.

A, engine crankshaft.
B, clutch-adjusting bolt.
C, sleeve carrying inner or movable part G.
D, crankshaft flange.
E, flywheel.
F, ring bolted to flywheel.
G, inner part of clutch.
H, driving jaw of clutch.
I, clutch leather.
J, lubricator.
L, clutch spring.

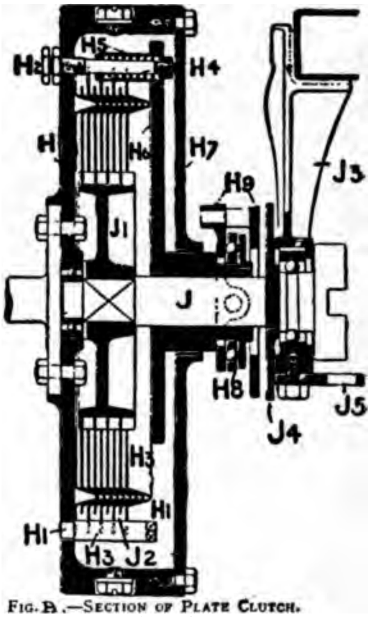


FIG. B.—SECTION OF PLATE CLUTCH.

H, hollow flywheel
H1, driving guide pins.
H2, screwed pins adjusting H4.
H3, driving disks.
H4, clutch springs.
H5, spring cases engaging with H6.
H6, Three-armed spider, controlled by H 9.
H7, cover (oil tight).
H8, ball thrust bearing.
H9, clutch fork mechanism.
J, shaft.
J1, driven member (externally toothed casting).
J2, slotted disks engaging with J1.
J3, bracket.
J4, brake flange to J.
J5, stay bracing to J3.

"The clutch is perfectly self-contained when engaged and there is no end thrust on the motor or gear-box; when the clutch is withdrawn the thrust of the coil springs is taken up rust ball-bearing placed on the tail shaft or rear portion crankshaft, and this construction permits the crank- revolve and the clutch to remain stationary.

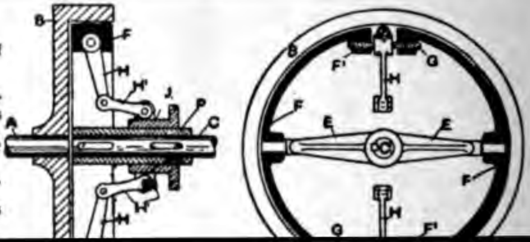
exible joint, perfectly universal in action, is interposed driving shaft between the clutch and the gear-box and intains correct alignment between the clutch and the l when the car is traveling over rough roads; it also es the removal of the clutch, should it be desired to do any time. The universal joint is constructed of forg- he wearing surfaces being hardened and ground. A aft, or removable spool, is placed between the gear-box

---

nkshaft.
forming outer part of

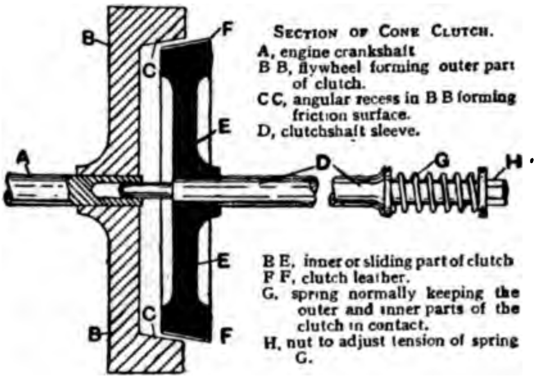
t.
ached to clutch sleeve
g the clutch segments

on the ends of the
FF.
l left-handed screws,
in the lugs F₁.
ached to the screws



through the countershaft to the front sprockets and thence to the rear wheels by strong roller driving chains of the best quality. Much attention has been given to the details of the double side chain drive in order that the mechanism may operate quietly and the adjustment and wear be reduced to a minimum.

"The transmission case contains the gears, shafts, bearings, and also the differential gear, a quantity of non-fluid oil being carried in the case which effectually lubricates all working parts. A vertical standpipe placed in the case enables the operator to insert the correct quantity of non-fluid oil. The use of ball-bearings in the gear box saves room, eliminates friction and permits the use of short shafts."



SECTION OF CONE CLUTCH.

A, engine crankshaft
B B, flywheel forming outer part of clutch.
C C, angular recess in B B forming friction surface.
D, clutchshaft sleeve.
B E, inner or sliding part of clutch
F F, clutch leather.
G, spring normally keeping the outer and inner parts of the clutch in contact.
H, nut to adjust tension of spring G.

Gear-drive transmission is fully dealt with under the headings referred to above.

CHAPTER VII.

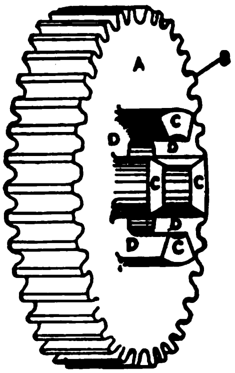
THE CLUTCH.

part that goes to make up the power mechanism of car has its individual importance as an essential factor whole. The subject of the Clutch, however, is of interest because the efficiency of the car depends so proper use by the driver. The exact character

Clutch systems may be divided into two broad classes—Positive and Frictional.

Positive Clutches.

These may be again subdivided into one-way clutches, such as a ratchet-wheel and pawl, or the type in which the jamming roller is employed, similar to those adopted in the generality of free wheel bicycle hubs, etc.; and dog clutches, in which square-jawed projections fit into suitably shaped hollows formed in the female portion of the clutch.



DOG CLUTCH.
A, Gear wheel.
B, Gear teeth.
C, C, C, C, Male portion of dog clutch.
D, D, D, D, Female portion of dog clutch.

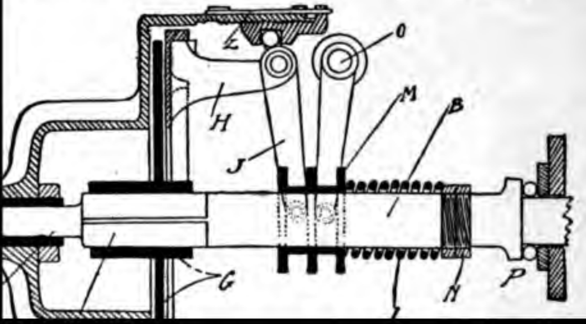
Friction Clutches.

As the name implies, the friction clutch is the type wherein the connection between the two parts to be rotated is supplied by means of friction. This type of clutch is the one most extensively adopted in automobile work, and many different forms are in use.

The Conical Clutch—The most common type is the conical clutch in which a coned member, generally formed by the flywheel of the motor, receives the male portion of the clutch attached to the driven shaft, the face of the male portion being

ered with leather. This part of the clutch can be
d out of contact with the female part and is normally
o its work by a powerful spring. The more modern
the advantage that it does not introduce any end
either shaft except when out of engagement.

r Disk Clutches—These are of comparatively recent
on, and have some most important advantages over
variety. These advantages are briefly as follows:
no fiber, leather, or other organic substance to wear
he clutch can run in lubricant which precludes any



faces, a little wear will require a great deal of adjustment—endways—to take up the amount which the clutch moves endways before it becomes really engaged.

A very simple form of disk clutch is shown in the illustration. It is fitted to some English cars and has been found to give excellent results. It runs in a bath of oil, so that there is no danger of any of the parts becoming dry or seizing.

The action of this clutch when disengaged is as follows: The engine in revolving turns the bell-shaped casting E. The friction plate G remains stationary on the square of the shaft B, and lies idle between the two plates E1 and F; meanwhile the oil is surging around between all three plates. On the clutch pedal being released the spring I forces along the grooved sleeve M, carrying with the latter the ends of the three levers J. These force the plate F to the left, and plate G is then firmly gripped between the plates F and E, thus transmitting the power to shaft B through the medium of the squared part C. The oil is squeezed out from between the four adjoining surfaces, and gradually the plate G begins to revolve, eventually being locked fast to the other two plates.

It will be seen that the action is quite gradual, and that however quickly the clutch is let in the film of oil between the plates will prevent its picking up the load suddenly. The absolutely flat surfaces and the great pressure applied to them, owing to the leverage gained by the long lever J with its fulcrum so near one end, insure a rigid contact between all the plates; and the shaft B, which transmits the motion to the gear box, turns as if one solid piece with the engine crank case. It will be seen that only the very slightest movement is necessary to engage and disengage the clutch. The thickness of two pieces of paper is sufficient distance between the plates to put the clutch out of action.

In the illustration, besides the parts already mentioned, A is the engine crankshaft, D a pin-bearing on the end of shaft B inside end of engine shaft A. H is one of three brackets on plate F to which the lever J is attached. K is a screwed ring in the end of the bell-shaped casting E, which can be and out and determines the normal position of the on plates. When the adjustment is made the ring y a locking spring L screwed to the bell-shaped is a lock-nut, by which the tension on the spring sted. O is a lever operated by the pedal and which the clutch. P is the ball thrust bearing which takes set up by the pressure of the spring I.

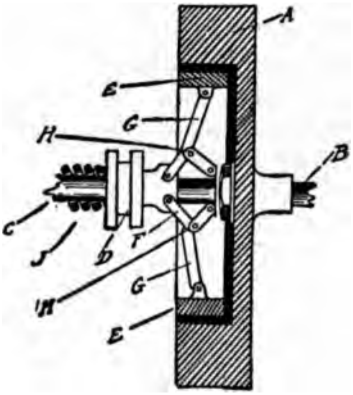
ltiple Disk Clutch—Another type of clutch which ery largely adopted is the multiple disk, in which large number of thin disks capable of moving laterally s to come into frictional engagement with each alternately anchored, as far as circumferential goes, to one or other of the clutch members. In the disks are corrugated, forming practically V n others they are quite flat.

bined Disk and Cone Type—A combination of the one clutch has proved very simple and "sweet" in consists of a series of thin steel plates of V section n a flywheel. The one set is in frictional contact ther, and together they transmit the motion from l to the driven shaft. The sets of plates are kept

A simple form of expanding clutch is shown in the illustration.

Usually the engine flywheel runs free of the clutch altogether, that is when the clutch is out of gear. When the clutch is put into gear the spring J pushes up the sliding sleeve D expanding the toggle joints H, H. These force out the segments E, E of the inner clutch member into intimate contact with the inner face of the flywheel rim. The toggle joints increase the leverage as the clutch is forced further into contact and only a light pressure on the spring J is necessary. It will also be seen that all end pressure set up by the spring is self-contained on the gear shaft C, and does not have to be transmitted through any bearing. This form of clutch, therefore, is absolutely free of end thrust, both when the clutch is in engagement and when it is running free. It is practically the only type in which this great advantage is obtainable.

A, Engine flywheel.
B, Engine crankshaft.
C, Gear shaft.
D, Sliding sleeve on gearshaft.
E, E, Segments expanding inside friction ring.
F, F & G, G, Link levers of the toggle joints H.
H, H. Toggle joints which force the clutch segments into contact.
J, Spring which keeps clutch in engagement.



Simple Form of Expanding Clutch.

In the De Dion expanding clutch the expanding segments are forced out by right and left handed screws operated by a central sliding cylindrical rack. This is now only used on one small type of these cars, to operate two speed gears, two clutches being used, one to each gear. Up to 1904 this system of clutch was in use on all types.

Rim or Contracting Clutches—These, unlike the expanding clutch type, grip the outer periphery of the constantly rotating member, instead of the inner circumference, just as a brake-band grips its drum.

Coil Clutches are not much used but there have been some notable examples of their use, as in the Mercedes cars, etc. In coil clutches the gripping action is obtained from the automatic tightening action of a spring steel coil upon the inside of a parallel or the outside of a conical steel drum. Where the coned drum is used, the longitudinal springing properties of the coil are employed to press the steel convolutions into contact with the driver, and where the parallel driver is used the gripping is initially obtained by the tendency of the spring to unwind itself and so expand.

Electrical Clutches—Of these the Belgian Auto-Mixte is perhaps the best known. It comprises an arrangement whereby, by altering the quantity of current passing through the clutch coils any desired amount of slip can be obtained without the great friction usually entailed. This clutch is said to give most excellent results.

The Clutch in Hill Climbing.

Many drivers resort to the slipping of the clutch to enable the car to surmount a hill rather than change to a lower gear. There are many who advocate such a method of driving, while, on the other hand, there are those who deprecate it. Without doubt, it may be said that the practice is a bad one on a long hill when the engine begins to flag early, but if it will obviate changing for just the last few yards over the crest of a rise there is nothing against the practice, except the slight extra wear on the clutch, which can be ignored when the clutch is properly designed and made. As some are not acquainted with this method of driving, we give the modus operandi of surmounting a hill by slipping the clutch. The object of the change-speed gear, of course, is to maintain as near as possible an equal engine speed, but it will be easily seen that when one is driving up a hill and the engine begins to lag, the clutch may momentarily be withdrawn, the engine allowed to pick up its speed, and the clutch gently let in again, when the momentum will be kept on the car for a short distance. Then the engine will begin to flag again, necessitating another brief release from the heavier portion of its work, after which it will again pick up the car. As a matter of fact, one has to keep one's toe on the clutch pedal all the time, and be prepared to let the engine pick up, though exerting some of its power in the propulsion of the car while the clutch is slipping. Many autoists have long used this method of surmounting the crest of hills rather than change speed for a matter of a few yards, and have not experienced any ill effects from it; especially when the clutch leather was kept in the best possible order and the adjustment maintained.

The novice, when he attempts this action, invariably makes the mistake of making the withdrawal of the clutch too deliberate, and thereby often fails in achieving the desired result. Those who have so failed should heed the following advice: Keep the heel down on the floor board, and keep tapping the pedal with the toe with a rapid but not too powerful stroke. This is much better than continued pressure.

Renewal of Clutch Leather.

If you find it necessary to take the gear-box down it would be as well to see that the clutch leather is in good condition, and if it shows signs of burning or is worn thin this opportunity of replacing the leather should be taken. With a little care in removing the rivets and taking off the old leather, it can be kept intact, and will be useful to mark out the new one, which should be cut from the thick part of the hide, and will not cost much. Be careful to countersink the holes for rivet heads, so that they sink well below the surface of the leather, and put it on rough side out. It will be better trued up in the lathe, but if carefully and truly fitted it may do without, and if soaked with castor oil will very soon accommodate itself to the female portion after the car has been run a few miles.

Attention to Fierce Clutches.

ıfort and safety of the driver and the efficiency of
ɔend upon the clutch to a very much greater extent
ıerally supposed by the average motorist. A fierce
s up its work too quickly, causing the car to jump
ith a bound upon starting, instead of moving off
in fact almost imperceptibly, at first. It is very ob-
the fierce clutch must put unusual strains upon
of the vehicle. It certainly does not impress the
when they are shot up in their seats and by the
comfortably settle themselves find the car traveling
venty miles an hour. This is particularly the case
ir first experience of automobiling. On the other
a properly graduated clutch the work is taken up
, all excessive strains are eliminated, and the pas-
ınot help admiring the ease with which the car is

clutch is often caused by the clutch-spring being
, and this causes an unusual amount of power to
to the clutch pedal in actuating the clutch, and

about half-way of the cone between the leather and the metal, and the leather again secured. The effect of these four or six disks is to raise very slight projections or bosses in the leather, which bosses, upon clutching, take up the drive first with a continually decreasing amount of slip until the whole surface of the cone is engaged.

Other remedies are: The application of neatsfoot oil; the treatment of the leather with castor oil, followed twelve hours later by a tablespoonful of kerosene; and the use of a mixture of castor oil and commercial glycerine. This must be well shaken up and then applied thinly and evenly.

Slipping Clutches.

A slipping clutch, on the other hand, is a source of constant annoyance to the driver, as much of the power developed by the engine is wasted by the clutch slipping instead of its transmitting the power to the road wheels for purposes of propulsion. It will usually be found that the cause of abnormal slipping lies in the fact that the clutch is in such a position as to take up a lot of the oil which is ejected from the crank chamber of the engine or the gear-case. If such is the case, the first thing is to find the course pursued by the oil, and to check it by means of a baffle-plate composed of a piece of tin, or if it should be leaking through the bearing one can usually manage to wrap about the shaft a few turns of ordinary worsted yarn, which will prove an effective stop to the oil excretions. Provided that the slipping is not due to over-lubrication, it may be found that the clutch-spring is too weak, and it is, of course, necessary to tension the spring up just sufficiently for it to transmit its full power and no more.

Drivers who suffer from weak ankles are particularly addicted to slacking the clutch-spring back, as in the course of a long day's run they suffer no small amount of physical pain if the clutch is at all fierce, while the time may come when the prompt withdrawal of the clutch may avert an accident. It should be borne in mind that if a clutch is allowed to go on slipping the leather will soon be charred and perhaps ruined.

Clutch Troubles.

a few cars the engine flywheel is secured to the
ankshaft by means of a tapered end into which is
y, the flywheel being held up on to the tapered end
of a nut and lock-nut. Beyond the flywheel lock-
crankshaft is continued as a small diameter spindle,
ch the clutch-spring is placed, this being retained
ted by means of nuts on the end of the aforemen-
indle. In assembling a clutch of this design, it is
ssary in the first place well to grease the spring,
perfectly certain that the spring abuts firmly against
part of the clutch, and not against the flywheel lock-
ould the spring take the latter position when the
withdrawn, a turning action is put on to the
ding to unscrew them. When the nuts are slacked
ciently to permit the flywheel to move, it is not very
re the key becomes damaged sufficiently to admit of
mount of movement to the flywheel, the result of
in all probability, a spoilt crankshaft.

the Clutch Leather—A most important thing in the metal outer clutch surface, and thus prevent the clutch working smoothly and gradually getting up way on the car. Some difficulty may also be experienced in taking out the clutch, owing to the seizing of the copper rivet heads on to the metal clutch. As it is rather difficult to obtain leather suitable for clutch work of any greater uniform thickness than a quarter of an inch, and some of this must be turned off in truing up the leather after riveting, there does not remain more than an effective depth of one-eighth of an inch of leather held by the rivet head, and this should be one-sixteenth of an inch below the leather outer surface, to allow for wear and compression. Those who experience trouble with fierce clutches should examine the rivets, and knock them lower if level with the leather outer surface.

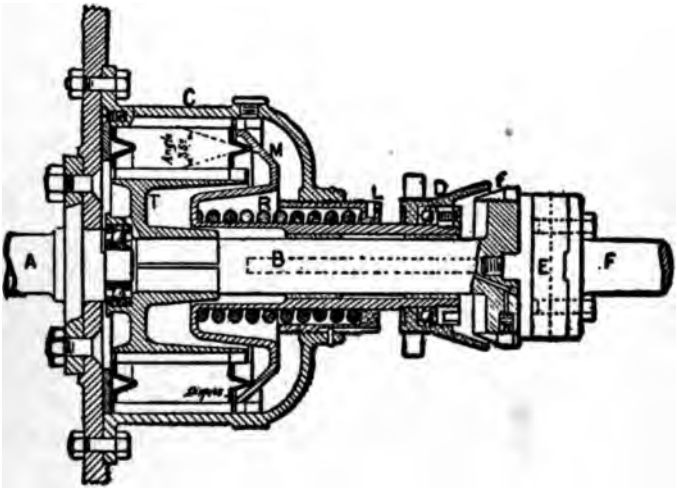
Interconnected Clutch and Brakes.

On a number of motor vehicles the foot brake lever and also the hand brake lever are connected to the clutch, so that on operating the foot brake or the hand brake the clutch is taken out of action. It is claimed that such a method is best for the novice, but some good authorities are inclined to doubt that such is really the case. It seems to them that with the flexible engines now fitted very little operation of the brakes should be required, as the whole control of the car, save in cases of extreme emergency, can be readily brought about by the operation of the throttle valve. A motorist who through his own fault has quickly to apply foot and hand brakes is one who should not drive a car, as evidently his judgment or his ability is at fault. For instance, on descending long, steep hills the car can be held under control in most cases quite readily by almost closing the throttle and retarding the spark, but oftentimes perhaps too great a speed will be attained by using the throttle and ignition solely. In such cases a slight application of the foot brake or the hand brake gives the extra check required; but if the application of one or other of these brakes disconnects the engine, one really good brake is gone, and the car immediately gets way on if the re not in absolutely good order. It will be seen that nsing with the inter-connections which can be readily many of the cars now fitted with them, a really valu- l additional brake from the engine is obtained. One od point in favor of the hand-applied brake taking clutch is that it is impossible to start off from rest hand brake on, simply because the clutch cannot be all without the brake is taken off.

Driving "On the Clutch."

earlier days of motoring, when engines would refuse lowly on half-throttle and used to stop dead as soon peed of rotation reached a moderate figure, say 300 ns a minute, many drivers used to "drive on the o avoid gear changes. To a small extent this is quite ble, and does no harm, but if this facility be used to he violent and continual rubbing will not only wear will also overheat and burn the clutch leather. A well and well adjusted modern 4-cylinder car, of say 20 ill, by a movement of the throttle alone, run from four end disk. The figure shows the V shape of the disks; in fact, the whole clutch is well shown here in section. The female cone D bears on the male cone "f" when the clutch is thrown out, thereby checking the spinning tendency of this clutch, or, if the viscosity of the oil is heavy, holding it quiet during the changing of gears by the motor car driver.

In place of the entire surface of the disks bearing, only the V portions engage. This clutch is copiously lubricated, and the V, or engaging portions of the disks, are perforated with holes so that the oil may circulate quickly in and out of the V grooves as they are engaged and disengaged. Outside the V portions of these plates or disks there is a comparatively large space between them, permitting the free circulation of oil and consequent rapid carrying away of heat if the clutch slips much in the operation.



The Hele-Shaw Clutch.

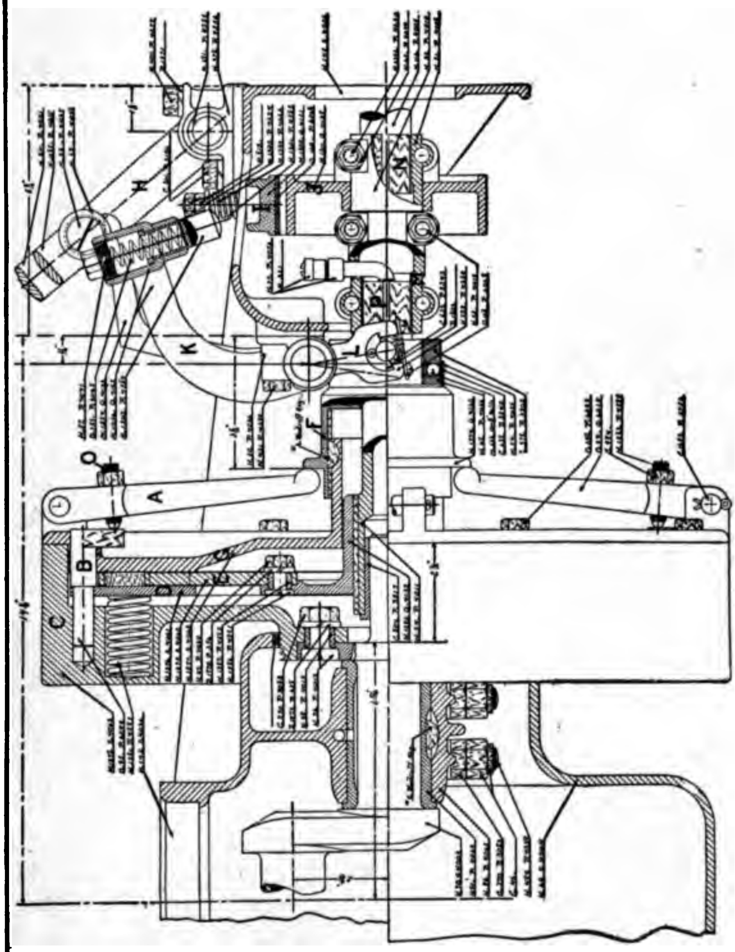
The number of plates in the multi-disk clutch is made to vary with the power transmitted, the diameters remaining the same within certain limits. The principle involved is that the thickness of the pack of plates shall not exceed the diameter *of the plate*. When this becomes necessary in order to tran mit a load, the plates are increased in diameter, fewer of them being used. The clutch is necessarily heavy, but this is partially offset by the relatively small diameter. It has, consequently, little spinning tendency.

A Typical Three-Plate Clutch.

The clutch fitted to the Knox Model "O" 38 H. P. car is typical of modern construction. See full-page illustration.

This clutch is of the three-plate type with cork inserts. The flywheel and clutch consist of four members; the flywheel proper, C; flywheel cover, G; spring plate, D, and the cork insert driving plate, E. This clutch is shown in the engaged position, the cork insert plate being tightly clamped between the spring plate and flywheel cover by the 16 clutch springs shown recessed in the flywheel rim. Each of these springs presses against the plate with a 60-pound pressure, giving a total pressure of practically 1,000 pounds to transmit the power of the motor through the gear set to the road wheels. This 1,000 pound spring pressure against the clutch plate is so reduced by the disengaging levers that a 25 pound pressure by the operator's foot on the clutch lever H releases the clutch and allows the gears to be shifted or the clutch to be slipped.

The disengaging action is as follows: the clutch lever being pushed downward, the sliding clutch collar F is pressed inward on the hub of the clutch cover G by means of the forked lever L and its connecting levers. This action is communicated to the spring plate D by the four clutch levers A and the disengaging pins B and adjusting screws O. As soon as the spring plate is pressed inward the cork insert plate E is freed of its spring pressure, and if the motor is in motion this plate will slowly stop revolving. To further the stoppage of this plate quickly, allowing the gears to be shifted noiselessly, a clutch shaft brake is provided. By referring to the cut, lever K is securely fastened to the clutch shaft and operates with it. At the instant the clutch plate is completely released this lever presses downward, striking the clutch brake shoe I and forcing this shoe by spring pressure only against



Knox Three-Plate Clutch Details. See Description on pages 148-150.

e drum J, thus stopping quickly the clutch shaft P smission shaft N, to which the brake drum is bolted. nox clutch is designed to be run practically dry, the claiming that with the use of cork inserts they can the use of an oil bath. The lubricating points are ers on the end of the clutch shaft P and on the slid- h collar F.

The Sturtevant Automatic Clutch.

llowing description of the Sturtevant automatic s used on the Automatic automobile, a machine of e design, will be found of interest to all motor-car

automatic clutch is applied to any gasolene automo- car can be controlled by throttle exactly like a steam nd have the same wide variation of speeds, from ll power, on all drives, and whatever engine is used. h requires no attention whatever; it grips of itself ut with ample power at exactly the right time and s to let go promptly when release is desirable. The nnot be stalled; therefore the car cannot run away engine. These give the necessary momentum to the enclosing flywheel shell, which consequently is not heavier than usual.

"Each lever weight (exactly as in a governor) is held in by a spring, and until engine rotations force the weights outward the clutch runs free. But when the weights do move out, by the centrifugal force generated by quicker rotations, the weight fingers gradually pinch the clutch disks together, and thus cause smooth grip; and when revolutions diminish, and lessen, centrifugal force permits the springs to push back the weights, their fingers gradually let go, and the engine is free. This is all. But the strength developed in these fingers by centrifugal action is astonishing.

"Efficiency of Automatic Slip—When common clutches are slipped to produce lowest car movements the motor must retain such considerable speed as will insure against stalling. Therefore the loss of its efficiency by slip is a serious consideration. But the slip of an automatic clutch (which can never occur until the motor has reached the lowest speed at which it can be trusted to run) is of negligible importance; because if with equal slip, one motor runs at twice the revolutions of another, the faster engine has only one-half the efficiency of the slower.

"Wear—How Prevented—Centrifugal multiple-disk clutches suffer no practical wear, because when they slip the motor has been throttled to run at its lowest dependable speed, and the weight fingers only squeeze lightly together the oily disks, which cannot then rub together destructively. The secret of centrifugal multiple-disk clutch construction is, first, to know at what pressure disk plates turning on each other at slow surface speed can endure continuous slip without harm, and then add enough disk plates to hold the whole power of the motor at this pressure. It is plain that under these conditions slip is absolutely impossible at higher speeds; and harmful slip is not possible at lessened revolutions. When these clutches turn faster, the disks are positively locked, because centrifugal force increases as the square of rotations, and imgrip pressures are quickly available when motor speed erated.

rief: Slow engine speed is the only thing that can automatic clutch slip; and because the pressures are ghtest, and the disk surfaces rubbing slowly in oil, s no harm. These designs produce smooth starting, e holding at the lowest speeds at which the engine to run.

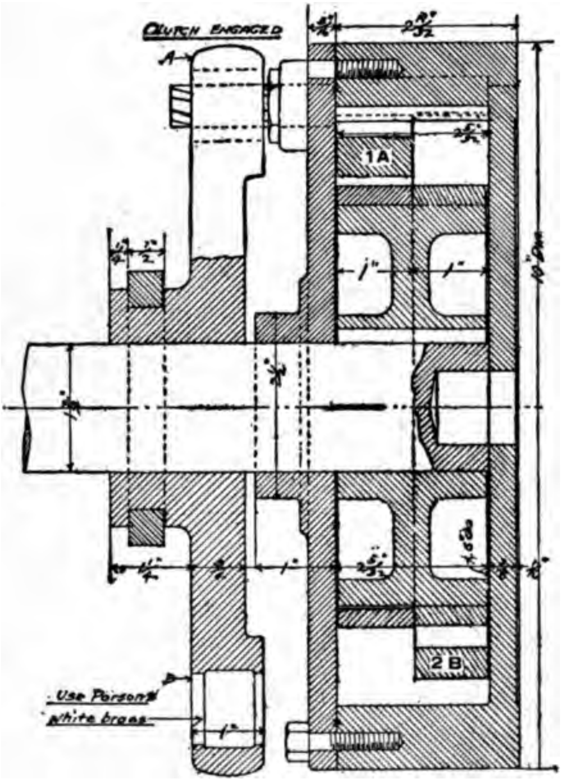
ll speeds above this, the clutch holds with much more han is needed. All other clutches slip, not when the is slow, but when it is going fast, and exerting too ower for the clutch. In all other clutches that do not hold the engine, the frictional parts rub together ey slip at high speed, and with destructive pressures. entrifugal disks, when they slip, rub lightly, and turn it would be strange indeed if they did not surpass all ictional clutches in durability."

The Warner Constrictor Clutch.

ent innovation in motor car clutches is the Warner ctor clutch, of which we show a detailed plan view on t page. Its construction is simple and strong. It

"Begin tightening up the set screw for the ring next to the flywheel (marked 2B on the diagram) until you can move the machine 'light' with the 2B ring alone. Then set the jam nut to hold the set screw in that position.

"Then throw the clutch out part way until the 2B ring is disengaged, and tighten up the other set screw until you can move the machine as before, by means of the 1A ring acting alone. Then set the jam nut.



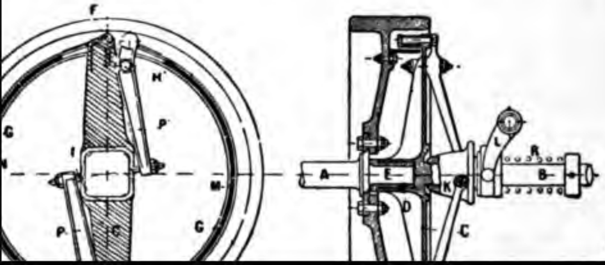
The Warner Constrictor Clutch—Plan.

"You have now a crude adjustment and can run the machine, without any feed or load, the A ring taking hold first and starting the machine, and the B ring following it; but

ings together will probably slip, owing to the loose
nt. If so, tighten the screws up alternately, a little
until the clutch will transmit the full power needed.
l not to set the clutch too tight. It should slip for
onds before the driving and driven portions of the
y travel at the same speed. The clutch may need
g up several times for the first few days, but there-
need no further adjustment for a long time."

ing Warner low-speed clutch is adjusted in the same
beginning with the set screw nearest the flywheel.

ors Clutch—This is a type of metal-to-metal clutch
ntraction principle. It consists of a drum attached



on bronze and steel disks with cork inserts. Regarding the use of the latter a well-known engineer writes: "I have recently been informed of a disk clutch with cork inserts of natural cork that wore out in about 1,000 miles twice in succession. This same clutch was equipped with compressed cork inserts, which have driven the car some 5,000 or 6,000 miles without perceptible wear."

Steel disks against steel have sometimes become badly heated and cut to such an extent as to make the clutches inoperative. Steel against bronze, however, does not seem to cut in this manner and the wear after two years' steady use is only 0.002 inch or 0.0003 inch at the outside edge of the disks.

Steel and aluminum enter largely into the construction of the most modern clutches and fiber is often used instead of leather as a covering for cone clutches. The fiber is sometimes interwoven with copper threads and springs are sometimes inserted beneath the fiber to prevent jerky movements of the car when the clutch is first engaged. It is claimed that this form of clutch insures smooth engagement and that the fiber covering is not affected by oil or water like a covering of leather.

CHAPTER VIII.

GEAR OR GEARING.

driving gear of a motor car, or those parts of the which are most nearly concerned in effecting motion, present time on motor cars are by —(1) Belt; (2) Chain; (3) Friction; (4) Spur (including various different types).

The reader must be careful to differentiate between "transmission" considered as a whole (dealt with under Transmission), and gear or "gearing" in its correct meaning. Two pulleys connected by an endless belt so that the one drives the other; two chain wheels engaging with a chain; two toothed wheels in mesh with each other; a screw in engagement with a wheel which forms an endless nut for it—all these variations constitute gearing, though not necessarily a transmission system in its entirety, or a change speed "gear." For example, an ordinary Panhard type change speed gear box consists of a combination of spur wheels, so arranged, however, that only two units of the combination are in mesh at one time. The two wheels in engagement, however, are, correctly speaking, the "gearing," and determine the ratio of the engine revolutions to those of the countershaft, or of the shaft to which the second wheel is fixed, irrespective of the rest of the combination in that position. The whole of the mechanism contained in the gear box is often loosely referred to as "the gearing," with a somewhat confusing generality that is misleading to the tyro when the term is used in its definite sense. The correct term in this particular case is the "Change Speed Gear or Gearing," and under this heading it is described elsewhere.

We shall now proceed to describe the different kinds of gearing under the heads already set down.

(1) Belt—Belt gearing consists simply of pulleys connected by an endless band or belt, and has been used largely in the transmission system of motor cars in the past, though such gearing is now obsolete. Belt gearing may be employed for transmitting power through parallel shafts, or by special arrangements from one shaft to another at an angle. See Change Speed Gear.

(2) Chain Gearing—This system can only be employed for transmission between two parallel shafts, and is largely used for conveying the power from the countershaft to the road wheels. Chains have also been used for change speed

and in some makes are at present fitted for con-
he power from the engine to the intermediate mechan-

riction—This class of gear is chiefly found in use with
ive speed mechanism, whereby a friction wheel is
against the surface of a metal disk. The smaller
is driven by the engine shaft, and drives the disk by
f the friction between the two.

Spur or Toothed—The last broad heading includes
different species. The most common is the ordinary
e, consisting of a series of teeth cut across the periph-
the wheel which engage with the teeth of another
On the form of the teeth and their pitch, the silence,
y, and strength of the wheels depend. In making and
g spur wheels, an imaginary circle is taken called
ch circle," and the pitch circle of the other wheel is
ct with this, the ratio between the two wheels being
rom the relative diameters of their pitch circles.

tooth is pitched at an exactly similar distance from than spur gearing, though the shape of the teeth follows an involute curve. These wheels are used largely in automobile practice for driving long shafts for the valve operation from the top of the cylinder, and run smoothly and silently, but the wear is rather heavy, and the end thrust set up, together with the sliding contacts between the teeth, render them unsuited for heavy power transmission.

Helical Gearing—Helical gearing is coming into use in motor car gearing owing to its smoothness of running and the small friction loss entailed by its use. With a helical gear each tooth forms part of a screw thread or spiral of very great pitch, and its formation makes it cross the face of the wheel diagonally. The fundamental idea is that the faces and flanks of the teeth come into and part contact in a more even manner than with the ordinary square cut teeth.

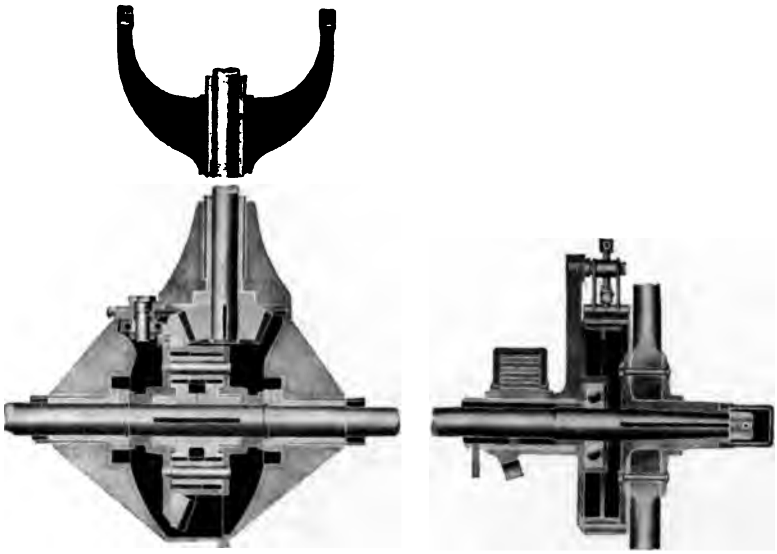
The spiral setting, however, ~~causes an end thrust; and with~~ a view to its elimination double helical or herring-bone gears are made. Double helical wheels consist of two ordinary helicals with oppositely cut teeth, clamped together so that the teeth correspond along the center of the wheel. With this arrangement the teeth appear to be V-shaped, with the point of the V in the center of the wheel. The right-hand section of the tooth sets up a thrust in a left-hand direction, and vice versa, so that end thrust is entirely absent. Gears of this type cannot be slid in or out of gear, and are only applicable for unvarying relative positions. They run very much more smoothly than ordinary spur gears, and give an even, silent drive, but they are expensive to cut.

Worm Gearing—Used in the steering apparatus because of its irreversibility, and in some cars for the transmission of the engine power to the live axle. Worm gearing has long been generally used for converting a high to a low speed for heavy mechanism or for very light work. Lately, however, improvements in the cutting machinery and experience of the type have rendered it capable of a much larger scope. The thread of a worm consists, of course, of a screw, which meshes with the female teeth cut into the worm wheel, and the ratio of the gear depends on the pitch of the screw. Where a high ratio is necessary the worm may have any number of threads cut on it at intervals around its circumference to enable the high pitch to be used. For instance, a 4-inch pitch worm would require to be of enormous diameter and depth were this to be cut right away, but by making four starts, equally pitched around the circumference, and cutting four separate threads, each having a pitch of four inches, the same result is attained, with an immense reduction of size and increase of efficiency.

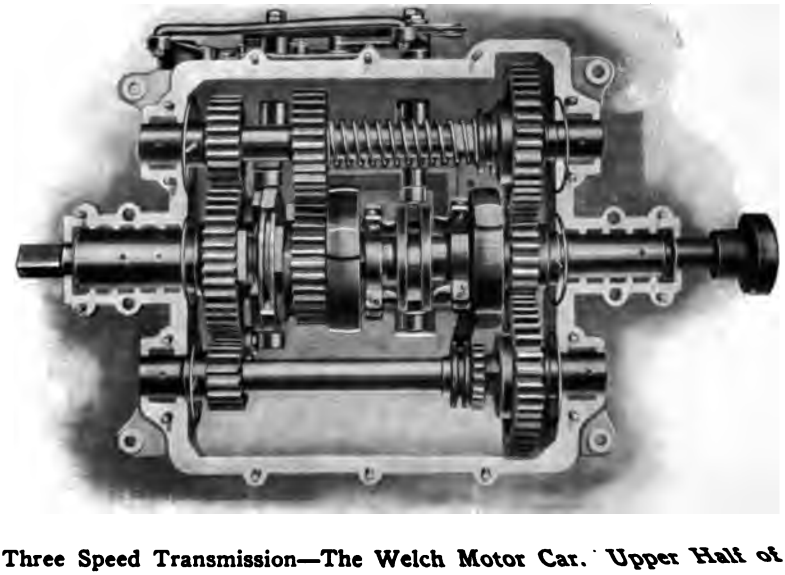
The number of independent threads may be increased within certain limits and depends on the pitch of each thread and the diameter of the blank.

Worm gearing gives an absolutely silent, steady, and powerful drive, and the recent improvements have obviated the irreversible motion hitherto considered inseparable from a worm drive. Wherever worm gears are used considerable end thrust is transmitted along the axis of the worm wheel. This is generally taken by a ball thrust collar.

Bevel Gearing—This is the most usual method employed for transmitting power from one direction to another at an angle. The faces of the wheels are conical, and so arranged that the sum of their base angle make up the angle at which the power is to be transmitted. The teeth are cut on these coned faces, converging to the imaginary apex of the cone. The shape of the teeth may follow either of the ordinary forms, and may be either straight, helical, or double helical. The first only are capable of being cut from the solid, and so are the only ones generally used. The defects of bevel transmission are: (1) end thrust on the bearings; (2) loss through transmission at an angle. Bevel gearing is, however, very largely used in the construction of automobiles, and when well made forms an efficient drive.



Rear Axle and Differential—The Welch Motor Car.



Three Speed Transmission—The Welch Motor Car. Upper Half of Case Removed.

CHAPTER IX.

CHANGE SPEED GEAR.

The relation of variable gearing to the rest of the motive mechanism of the automobile is indicated in the chapter on "Essential Parts of a Motor Car." The selective sliding type is now in general use. By means of this varying speeds are maintained at the will of the driver by the operation of a single lever and the use of a selector bar or other device to secure the engagement of the sliding wheels required.

Gear, Change Speed—A gear device whereby variable speeds of a motor car can be secured while the speed of the engine and countershaft remains constant.

To a certain extent variable speeds can be secured on a level road without slipping the clutch or altering the gear, solely by means of the so-called "flexibility" of the engine, the driver having merely to close the throttle and retard the spark to attain to the slowest speed.

A car with a 16 to 20 H.P. engine can, without employing any of the changes of gears provided in the gear-box, start from rest on the level and pass through all the ranges of speed up to 30 miles per hour. There has been perhaps 3,500 pounds, total weight, in each case, and yet with favorable to 35 miles per hour has been touched on the same is was done, moreover, without "slipping the clutch" ing the first 50 yards of the start. Nevertheless the essential, and here is the reason: A 20 H.P. engine give 20 H.P. at or about one particular speed of rota- 900 revolutions per minute, corresponding to a road let us say 24 miles per hour on the "direct" or top t all less speeds it develops less horse-power. Now ce in the course of every journey it is found that the er is desired at moments when the engine cannot at- revolutions per minute on the top gear because the too heavy for it. Slowing of the engine from this curs at every moderate hill.

oderate hill can be surmounted at say, 10 miles per when effecting this the engine is not working at 20 is working at half-speed and therefore at about half- ay at 10 H.P. If we could relieve the engine so that rotate more rapidly and give 20 H.P., we could evi- avel faster than 10 miles per hour. It is to give this the engine while the car is traveling that the change shown in Fig. 1 is in engagement none of the other gear wheels are being used to transmit any power. They are all rotating idly and therefore silently.

It is as well to realize that the direct drive plan involves a less efficient transmission on all the gear ratios other than the top. See the last paragraph in the article on Gear Efficiency.

In the ordinary gear wheel sliding type of variable speeds on "second gear" or "first gear," four gear wheels must be in mesh in each case, whereas in the direct drive gear-box Fig. 1 shows that in no case (except reverse) are more than two gear wheels in mesh.

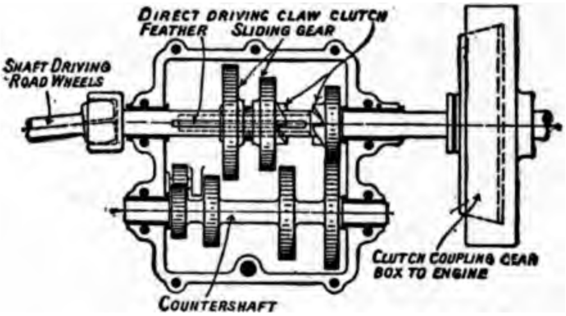

DIRECT DRIVING CLAW CLUTCH
FEATHER
SLIDING GEAR
SHAFT DRIVING ROAD WHEELS
CLUTCH COUPLING GEAR BOX TO ENGINE
COUNTERSHAFT

Fig. 1—Diagram of Gear Box showing three speeds forward and reverse with direct drive.

The reverse employs three gear wheels in mesh in both cases, so that there is no superiority on either side.

Both systems are in use on various cars, as is a third, which arranges that even the idle rotation of the driven gear wheels is avoided.

This third plan has, however, a certain drawback in the fact that when the driver is compelled to change to his lower gears he has a slightly more difficult task, namely, to thread into one another the teeth of two pairs of wheels simultaneously.

Other Drives—Many earnest attempts are being made to displace entirely the expensive mechanism of the gear-box, and these efforts will probably be crowned some day with success. The methods of attack of the problem are numerous:

Belts (almost abandoned).

Friction disks, from which the drive can be taken at t of a diameter (experimental stage).

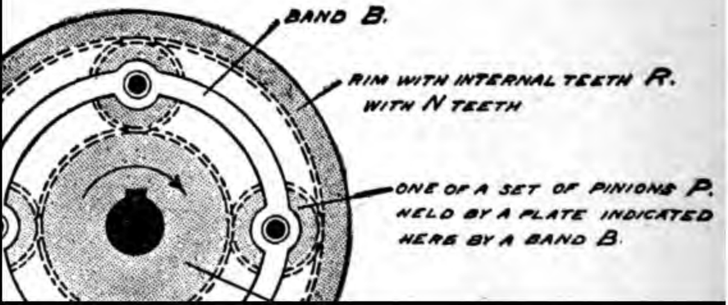
Epicyclic gear.

dle pinions clutched when wanted.

dle pinions keyed by a sliding key when wanted.

Electric transmission, as the "Auto-mixte."

nfinitely variable gears by altering the "throw" of a by varying the duration of time during which the transmitted.


BAND B.
RIM WITH INTERNAL TEETH R. WITH N TEETH
ONE OF A SET OF PINIONS P. HELD BY A PLATE INDICATED HERE BY A BAND B.

small pinions, finds itself obliged to rotate bodily in the same direction as the inner wheel W, but at a much slower speed. The band B may be replaced by a circular plate, which is rigidly connected to the chain wheel, driving the road wheels of the car; when the brake shown is applied to the rim, the chain wheel rotates forward at the slow speed.

To calculate the speed at which the band B, and with it the chain wheel, rotates when we know the engine speed is easy:—

Add the number of teeth on W to the number of teeth on R and divide this into the number of teeth on R. This fraction gives the ratio of the speeds of the chain wheel (or the band B) to the engine shaft, which is usually keyed to the toothed wheel W.

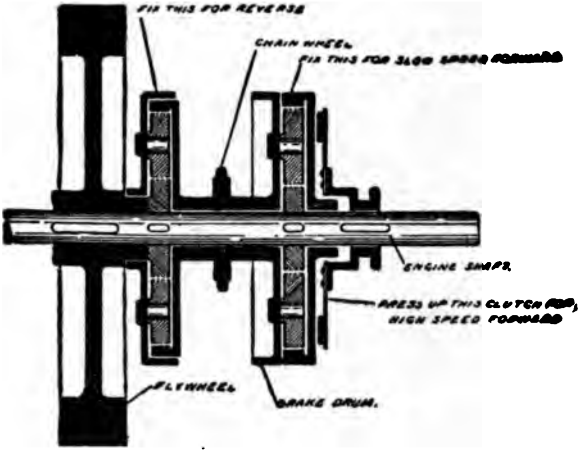

FIX THIS FOR REVERSE
CHAIN WHEEL
FIX THIS FOR SLOW SPEED FORWARD
ENGINE SHAFT
PRESS UP THIS CLUTCH FOR, HIGH SPEED FORWARD
FLYWHEEL
BRAKE DRUM.

Fig. 3—Section of Epicyclic reverse and slow forward gear.

A neat example of utilizing this gear occurs on the earlier Oldsmobile and Cadillac cars, one of which is illustrated in section above (Fig. 3).

The third, fourth and sixth types of gear above noted are the most promising.

The flexibility of modern motor-car engines, and the normal employment of much larger horse-powers than formerly (12 H.P. meant a racing car some ten or twelve years ago) has given a new lease of life to the stepped changes of gear. The gear is changed comparatively seldom, the tooth cutting is better, so that the noise is less, very superior gear steels have been found, and in many cases such a quality of steel is used that it does not require case-hardening, and therefore there is no warping of the metal.

Infinitely Variable Gear—This must not be dwelt on at length, as it is not yet in the commercial stage, but one type may be briefly explained. The ratchet or free-wheel type is exemplified by the Newman gear.

The engine shaft has an eccentric on it, and the amount of eccentricity is variable by hand. At each rotation the eccentric gives a to-and-fro motion to a free wheel on the rim of which is mounted a toothed wheel.

If the eccentricity is large, the to-and-fro movement is large, and the free wheel gives a large angular movement to and fro, but in one direction the free wheel merely slips in the toothed rim. In the return direction it drives the toothed rim, and so propels the car. The difficulty is clearly to get a "free wheel" which will stand such frequent shocks.

Despite what has often been said to the contrary, the importance of an infinitely variable gear is enormous to the motorist, and it is very seriously to be regretted that the efforts made have not yet been more fully successful.

CHAPTER X.

DIFFERENTIAL GEAR.

Gear, Differential—A differential gear, sometimes called a "balance gear," is a simple device which is misunderstood by the average car user, partly because it is never very accessible, and partly because it is very difficult to describe on paper. A British writer says: "In 1827, some of the motor 'buses which profitably plied for hire about Cheltenham and in London, had each of their wheels fastened by a pin to a solid rod of iron which constituted the live back axle. In several of these 'buses the axle was driven by a chain, but none of them had a differential. It is instructive to learn what happened.

"When they wanted to turn a sharp corner, say to the right, it was noticed that the inner or right-hand wheel had to traverse a much shorter circular path than the outer or left-hand wheel, and consequently had to make less revolutions than the left wheel. But the axle, which was coupled rigidly to both wheels, opposed itself to this difference in the amount of rotation, and rendered it mechanically impossible for the two wheels to turn at different speeds. It therefore became the custom to stop the car at a sharp corner and pull out the pin which fixed one of the wheels to the axle (preferably the inner one on the curve). (See Blue Book of Committee Report on Steam Carriage on Roads, 1831.) On removal of the pin this wheel was then no longer a driving wheel and the axle could freely rotate inside its hub, while the outer wheel was driven by the engine as before, and traversed its longer circular path without difficulty.

"Provision was doubtless made to prevent the loose wheel from slipping off completely during this manoeuver. When the corner had been turned, the pin would, in the ordinary course, be reinstated, but it is in human nature to suppose that

was entirely
wheel, and on coming to hills this w
evidence before the Committee shows t
ists made a practice of stopping near t
rake their fires and get up steam, thus
nity for replacing the pin.

"It is probable that turning to the
turning to the left when the right-hand
in neither case was the turning so hard a
to be bodily scraped across the ground.

This plan of freeing one wheel foresh
ployed a few years ago on very small
resuscitated) of employing a "free wheel
back wheels of a car instead of a differen

All this impresses the fact that ever
car requires the wheel on the outer si
rotate faster than it did when the car was
wheel on the inside of the curve obviousl
that in a conceivable case (on a very sh
wheel might have to be almost stationar
while the outside one would run round it

Nowadays, we recognize this fact, an
from one another we cut the axle in t
axle corresponds to

figure simply for convenience. (The propeller shaft arrangement will be shown later.)

This pulley has a hub or center which allows it to spin freely on the projecting pieces A and B of the cut axle of Fig. 1. From the hub three or four round spokes are used to support the belt pulley's rim.

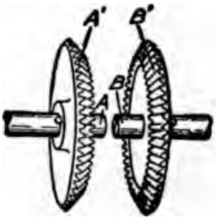


Fig. I.—A Bevel Wheel fitted to each half axle.

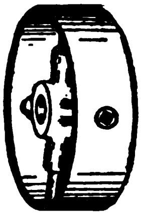


Fig. II.—Belt Pulley, arranged to run freely between the two bevel wheels A1 and B1 in Fig. I.

If it be put in position and driven by a belt from the engine it will not drag the two half shafts round with it unless at least one of its spokes is fitted with a small conical pinion C. To show this clearly Fig. 3 is drawn, which is Fig. 2 turned round a little more so as to disclose the bevel wheel. We shall not have to introduce another bevel wheel or pinion or mechanism or complication of any sort. We have, in fact, a complete differential or "balance gear" in this very simple system, and every other kind of differential in daily use, no matter how complicated in appearance, is the same as this and can be understood by having understood this.

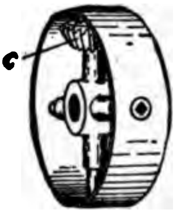


Fig. III.—Same Belt Pulley fitted with a conical pinion on one spoke.

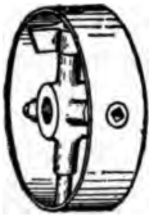


Fig. IV.—Same Belt Pulley fitted with pivot bar instead of pinion.

When the belt pulley is turned round, it is clear that either (1) both half axles must turn, or (2) half axle A must turn, or (3) half axle B must go round.

If there is no friction, that is, if no one grasps either of the half axles in Fig. 1, both will rotate at the same speed as the belt pulley, so that the central pinion might just as well be replaced by a small pivoted iron bar as in Fig. 4. The ends of the iron bar are cut on the slope, so that they should fit between the teeth of the bevel wheels A and B, Fig. 1, and to prevent the bar from falling out, it is pivoted loosely on to one of the round pulley spokes, as shown.

The two arms of this iron bar are like the two equal arms of a balance. If there be equal pressure or equal resistance to motion on the two arms of a balance, whether this resistance be large or small, the balance arm does not turn. If there be an excess of resistance on one side, the bar turns or yields on that side. If we call the movement of the balance arm, on which there is the excess pressure, a backward movement, the arm on the other side moves forward by an equal amount, until, if the excess pressure continues, the balance arm slips out from between the teeth of the two-side bevels. This gives us the reason why a little pinion, as in Fig. 3, is used instead of a bar. Its action is exactly the same as the bar, but it has this advantage over the pivoted bar on the balance arm, that when a large "out-of-balance pressure" is exerted and maintained, another pair of teeth come into engagement with the teeth of bevel wheels A and B.

Let us now consider the whole appliance in action. When the car is traveling forward, driven by the belt pulley, the pressures on the two arms of the bar are equal to one another. When, however, the steering wheels are deflected to one side, it is clear without any mathematical demonstration that the car no longer rolls forward as easily as if all the wheels were pointing in the same direction as that in which the car is traveling. The steering wheels therefore introduce a resistance to forward motion, which may be slight or may be great, according to the amount of deviation from a straight course, and this resistance is not the same on the two sides of the car. There is, in fact, a greater resistance to forward movement from that steering wheel which is on the inner side of the curve. On a motor car the steering gear is so contrived that whichever front wheel is the inner wheel (and therefore runs round the smaller radius of a curve) is always more deflected than the outer wheel. To a person who has never owned a motor car the same fact can easily be brought home by a simple experiment with any wagon or four-wheeled carriage. Turn the front wheels of the wagon round through a sharp angle, and then attempt to push the wagon by hand from the back wheels. First try pushing at a spoke of the inner back wheel, and then try pushing a spoke of the outer back wheel. It will be found that when the outer back wheel is being pushed the wagon is moved very much more easily.

In other words, an excess of resistance is offered by the inner back wheel, that is, the wheel which is on the inner side towards which the steering is deflected. If the belt pulley of Fig. 3 or Fig. 4 is driven round by the engine, exerting continually a certain effort, that effort is always, and under all circumstances, divided into exactly two equal parts by the balancing effect of the pinion (or the lever arm of Fig. 4), but whichever half axle offers the less resistance obviously turns more easily precisely in proportion as the resistance is less. So the differential gear performs its function, and drives the outer-driven wheel to turn more than the inner wheel, and this difference is the greater the sharper the curve.

A Second Explanation.

As one man's difficulty in understanding a mechanism is not the same as another's, so it may be useful to some readers to have a totally fresh and independent explanation from a different standpoint. Here are, therefore, two illustrations, and some very lucid text which originally appeared in The Horseless Age.

In Fig. 5 A and B are two racks—that is, straight, rectangular bars with teeth cut on them. These racks are rest-

the guides, then the two racks w
the pinion will not turn, but will re
position to the racks.

If we add to the weight W^1 anoth
lifting force to the yoke, then the re

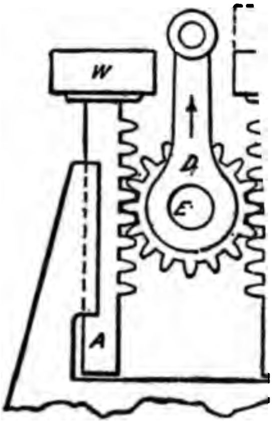


Fig. V.—Model to explain di

B being greater than the resistance o
stationary. A will rise and the pinion
E. This is under the supposition th
W^2 more

applied at the shaft of the pinion, to which in the figure a handle is shown attached, but which in practice is connected with a sprocket or chain wheel. As long as the resistance to motion of the two bevel wheels A and B is equal, the pinion C will not turn on its center D, but will simply rotate round the center of the shafts F and G, which are the two halves of the driving axle, and will carry the bevel wheels A and B along with it, the two (A and B) thus rotating at the same speed.

Now, suppose that the resistance to rotation of B becomes greater. This occurs when the steering wheels are turned to that side. Then pinion C will begin to revolve round its shaft and allow bevel wheel A to turn faster than bevel wheel B. These two bevel wheels are connected through the two half-axles to the driving wheels, and hence, if these bevel wheels turn at different speeds, the driving or road wheels do also.

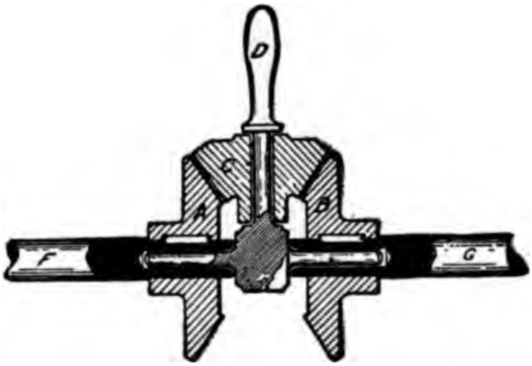


Fig. VI.—Model of Bevel Differential.

In the crypto type of differential many makers utilize flat gear wheels instead of bevel wheels, because they can be more accurately cut, and from that point of view this form of differential is an advantage. Purchasers are prone to pay insufficient heed to the differential being of good make and free running. It is probable that if they realized what a difference a good differential may make to the life of the driving wheel tires, they would alter their attitude in this respect.

Although we have now described everything in a differential, we must not forget that in ordinary parlance the term is erroneously used to include a great deal more, namely, everything contained in the differential case.

If, in place of the belt drive employed in the example (Fig. 3), another mechanical drive, namely, a bevel drive, were used, the addition of the external bevel wheel and its pinion would lend to the gear the appearance of Fig. 4. But we must not be led to suppose that this driving gear is essentially part of the differential. It has nothing to do with it. It is merely placed in a case in close proximity to the differential. Lastly, it may be said that instead of one pinion C being placed on only one spoke, it is usual to place two or three such pinions all performing exactly the same function on the other spokes, and further, if the drive shown in Fig. 7 is adopted, the side thrust due to this form of drive must be taken by thrust bearings, which are usually ball bearings. All these extra details are shown in the completed figure of an actual differential gear (Fig. 8).

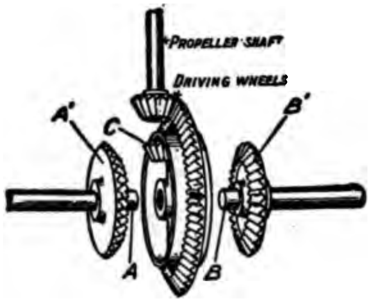


Fig. VII.—Complete Differential showing bevel, drive and pulley.

Further Effects of the Differential—If the car be jacked up so that both driven wheels are clear of the ground and if the engine be run so as to drive the wheels round, they will turn at the same speed if they are equally free from friction and if the brake bands are clear. If now one wheel be stopped by hand, the other will be found to rotate at double the previous speed.

If the engine be stopped and the brake be applied to the propeller shaft so as to lock it, it will be found that if one of the driving wheels be turned forward by hand, the other wheel will rotate backward by a precisely equal amount, and at the same speed.

The knowledge of both these facts is important to the driver of a car because of its bearing upon the best way to avoid skidding, side-slipping, and indirectly the excessive wear of tires.

In the course of ordinary straightforward running the differential is always slightly in action, because the adhesion of the two driving wheels is never exactly the same. That is (1) owing to the uneven distribution of the weight of the passengers, or because the car itself never weighs exactly the same amount on both driving wheels; (2) owing to the surface of the road being invariably different to the two wheels to a slight degree. Thus either a road depression is under one wheel or an excrescence is under one wheel or a more slippery surface is under one wheel.

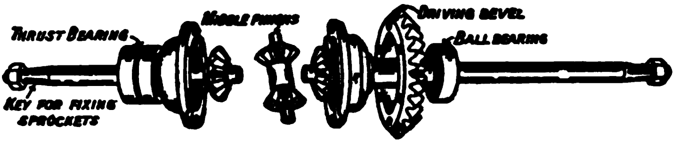


Fig. VIII.—Complete Differential as used on car.

Now, no matter what difference of adhesion there may be between the two wheels and the ground, the differential provides that no more effort can be exerted on the wheel which has the more adhesion than on the wheel which has the least. Thus the forward effort on the car can never be more than that due to twice the smaller adhesion, and further as the efforts from the two wheels are always equal, the forward effort on the car is always applied to the car, as it were, from the center of the back (or driving) axle. If the wheels were keyed solidly to a solid axle without differential, the wheel which had the best adhesion with the ground would obviously transmit the larger part of the forward push, so that the resultant push or effort from both wheels would not be at the center of the back axle, but nearer to one side, the side of better adhesion.

This then is an advantage of the differential when the car is in use on the road in many cases, but in some of the situations which arise in the course of traveling by road, this very merit presents certain complementary disadvantages. Thus if, as often happens, one driving wheel has good adhesion, while the other is on very slippery ground, it is evident that the differential prevents the wheel which has good adhesion from driving the car forward with any better effect than if both wheels were on the same slippery piece.

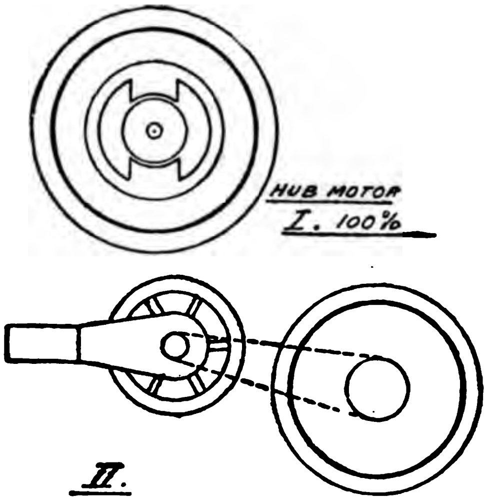
The good adhesion of the wheel which is on good ground is, of course, capable of preventing side-slip of the car, but it is not capable of being utilized for forward propulsion beyond the amount which is possible to the other wheel on slippery ground.

In other words, a car which had a solid axle without differential should travel forward more quickly on a surface of which some parts were more slippery than others, because it would invariably be able to utilize to the full for forward effort whichever wheel presented the best adhesion, plus the small, but still not negligible effort on the other wheel. This advantage, and a certain superiority in avoiding side-slip, would also accrue to a car fitted with two "free wheels."

GEAR EFFICIENCY.

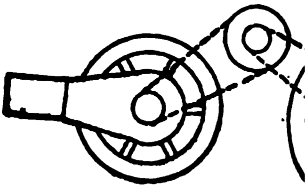
Users of cars cannot fail to be interested in the following figures of efficiency for various kinds of gear road wheels and tires. They are reported by a European authority from electrical experiments by Mr. R. Lacau.

"As an instrument of research electricity is invaluable in this as in every other industrial field, because it allows of the use of accurate measuring and recording instruments, which eliminate personal error and enable a whole laboratory to be transported readily to the scene of the test, even on a motor car. One of the most striking results thus measured is perhaps the high efficiency established for a well greased roller chain in spite of its exposure to air and dust. Ninety-four per cent of the energy put into a roller chain in actual use on a car re-appeared as energy on the back sprocket, and whereas a pair of steel spur wheels similarly exposed only returned 90 per cent. These were the figures for new apparatus. When the chains were worn, the number fell to 92 per cent, but when the spur wheels were worn the number fell to 80 per cent, and this is where the important difference comes in from the point of view of the power. Spur wheels, it will be urged, are not generally run exposed to the dust and air, but in gear-boxes full of oil. Under this condition 92 per cent of the energy put into the first wheel was obtained from the second when all was new, and only 90 per cent when worn, so that even the new spur wheels cased in were only about

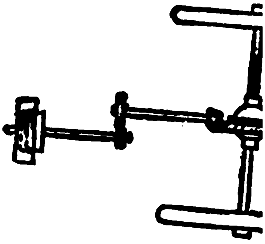


I. The most efficient drive. No gear reduction. Electric motor on the axle.
II. The second most efficient drive. One chain reduction. The motor and road wheels rotating in the same plane, 94 per cent. when new, 92 per cent. when worn.

well cased, run
afforded 88 per cent, or when old
The bevel wheel arrangement is in
car associated inevitably with the



III.

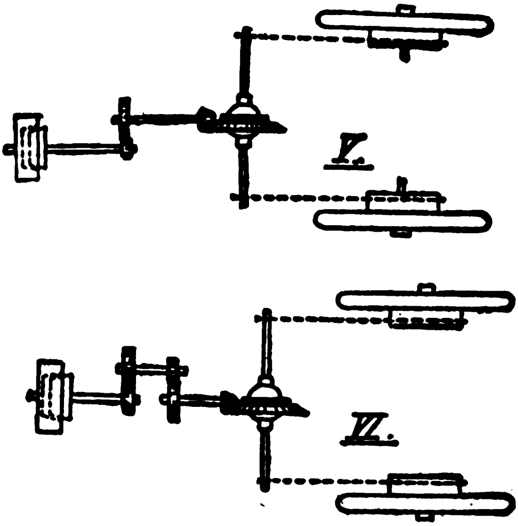


III. Two reductions of speed by chain, 88 per cent. when
IV.
cent." when new," 65 per cent." when worn. but power taken

joint. It is not always appreciated tha
wastes power. It does not waste much
it does

point for the moment being efficiency of transmission, there is no question but that the chain is shown by experiment to be superior.

"In view of the great demand for very silent drives, even for auxiliary plant, such as pumps, magnets, etc., the steel pinion and fiber ring, and the rawhide pinion with cast iron rings have an interest, inasmuch as it is perfectly legitimate for an intending purchaser to ask himself whether he would prefer to consume a little more fuel and travel more quietly, and if that be all that enters into the problem he would probably consider it wise to prefer the quietude and pay the price. The efficiencies of these two silent combinations appear to be in both cases 88 per cent with new gear and about 80 per cent with worn.



V. Three reductions of speed, one being right-angled drive, 74 per cent. when new, 69 per cent. when worn.
VI. Four reductions of speed, one being right-angled drive, 67 per cent. when new, 49 per cent. when worn.

"It must not, however, be assumed that because it is easier to make the fiber and rawhide combinations more silent than the plain steel ones, that in certain conditions it is not pos-

[illegible] they were glad to have Mr. experiment of a careful kind to show t on which the tests were taken at 13 mil macadam, free from dust, the tractiv lbs. to 40 lbs. with solids; 44 lbs. to 53 matics; 53 lbs. to 62 lbs. with the s inflated; and 64 lbs. to 71 lbs. with matics on the same car."

CHAPTER XI.

SPUR OR TOOTHED GEAR.

Gear, Spur—Gearing composed of spur wheels, the latter being the ordinary form of cogwheels. The cogs are radial and peripheral, and are adapted to engage countershaft cogs on another wheel. The pitch-lines of the driving and the driven wheels are in one plane. See Gear or Gearing.

Spur wheels or toothed gear wheels are liable to damage from the following causes:

(1) From being overloaded, or asked to transmit an effort greater than the engaging teeth are jointly strong enough to bear, for example, when a countershaft brake is used too violently.

(2) From being mounted on engaging wheels whose axles are badly aligned or at the wrong distance apart.

(3) From being badly cut, or cut to a bad profile.

(4) From being badly handled by the driver in one of four ways:

- (a) Allowed to drive when only in partial engagement.
- (b) Allowed to take up the drive with a blow or shock, instead of taking up the pressure gently.
- (c) Brutally forced into engagement.
- (d) Being neglected as to lubrication.

All these cases are really methods of obtaining an overload on the teeth.

skilled owner to detect.

Meshing—It is fairly easy to know i wheels are not meshing properly, that nical terms, if the pitch circles are no To begin with, the gear will be noisy.

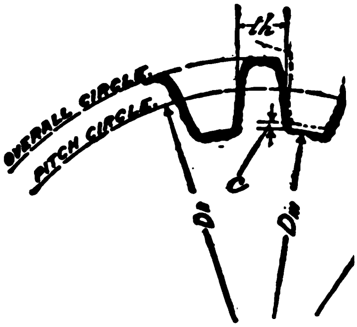


Fig. 1—Showing Overall and Pi

deep the tips of the teeth on one wheel into the spaces on the other wheel that C on Fig. 1 will not exist, and the end continually in compression. The obvio ever, is this: Measure the distance b the engaging spur wheels and deeply or too little, there is rubbing and crushing of the surfaces and loss of efficiency, particularly with cycloidal teeth.

Shape of Teeth—In (3) the effect of a tooth being a bad shape is that even though the whole width of surface is operative the root or other part of the tooth has been made too thin for the pressure to be transmitted; it is therefore overloaded and snaps. Involute teeth are preferable to cycloidal in the gear-box.

Partial Engagement—In (4) if a careless driver leaves the speed lever in an intermediate position between the notches, or if the quadrant which carries the notches is strained over by rough usage, only a fraction of the width of the tooth is operative and overloading of that fraction occurs, so that either a piece chips off or the metal crushes and flows generally so as to make a burr on the edge of the tooth. If a piece chips off there is grave risk of much expensive damage resulting from the piece, even if quite small, getting jammed between another pair of teeth and snapping either one or other off. The freshly broken tooth may then chance to drop between two other wheels rotating in engagement, and it will ruin them also, whether or not they be transmitting any power. This possibility of damage being done to gear wheels which are rotating idly, by the accidental intrusion of foreign matter such as a flynut belonging to the lid of the box, is a slight drawback to the type of gear-box which employs such idly rotating wheels, apart from the objection to the noise and the waste of power. The latter, however, need not be important if the gear-box be fitted with ball or roller bearings.

Fierce Clutch let in badly—A cause of damaged gear wheels is sometimes the accident by which one's foot slips off the clutch pedal. If it be very fierce, and the engine running fast while the car is nearly stationary, a considerable jar results. It is true that the factor of safety, or the margin of strength of the teeth, ought to be sufficient to allow for all such eventualities as may legitimately occur to a careful driver, but the size and weight of parts is very closely cut in motor cars,

(3) To bad alignment of the axes

(4) To bad distancing of the whe cycloidal teeth.

(5) To sliding wheels badly cent

Warping takes place in manufact hardening the surface of mild steel grinding teeth after they have been l it is often avoided by the maker, an matched with one another after hard trial and error till a silent pair is fou

It is well to remember that silent not necessarily a sign of perfection of viously if the hardening process has be will have been no warping, and the (machine cut with great accuracy in make any noise till the absence of vealed by the rapid wear. As a test not cut the face of a hardened mild ste with difficulty, and the roughness of t the attempt.

Latterly, and in some of the very culiar steels with terials, analysis or full mechanical test should be made of the steel.

Noise of Gear Changing—The noise of gear changing must not be confused with the noise previously alluded to made by the gears after the change has been effected. Gear changing with "clash" gear of the sliding type is noisy when the sides of the teeth which have to be pushed past one another are not rounded off, or when the rounded sides have been bruised by the driver using too much force in effecting the change, or by the driver attempting to change without keeping the clutch pedal fully depressed.

Even when the clutch pedal is fully depressed it is important to remember that the light or inner part of the clutch has a certain inertia of its own and tends to continue revolving after it has left contact with the fly wheel. It is only when this movement has reached a certain value that the ideal condition for sliding the gear occurs. That condition occurs when the teeth which are coupled to the road wheels move at the same speed as the teeth which are driven round by the inertia of the clutch and are about to be thrust between them.

To facilitate the getting of this condition during the driving of the car a small brake pad is often arranged near the back of the clutch, so that when the clutch pedal is fully depressed the clutch cone (male part) comes into frictional contact with the brake pad.

A better arrangement still is provided by some designers, who make the male part of the clutch and the gears to which it is connected of such small size and light weight that they have but little inertia and therefore easily take up any speed or change of speed which may be impressed on them by the gear wheels they are lightly put into contact with.

Broken Toothed Wheel—If it is not convenient to get into touch with the maker of the car (as often happens when one is in a distant state) the correct replacement of a broken gear wheel is a difficult matter. It will be facilitated by sending to the best local gear cutter either a broken part or a "rubbing" on paper made from the profile of the tooth, provided

file be not rounded off, accompanied by a dimensioned
the gear wheel and stating the number of teeth. One
ay with advantage be roughly sketched, and the di-
s carefully taken and indicated on the sketch.

imensions given must be (referring to Fig. 1) as fol-

I. The diameter of the overall circle, or of the "pin-
blank."

II. The diameter of the wheel a the pitch line.

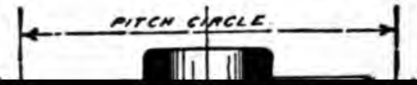
III. The diameter of the circle at the root of the
n.

. The height—(that is, the working height inclusive
e clearance C).

h) The thickness.

be seen that the essential thing to find is the pitch-
eter.

pth and width of the tooth must also be given.



CHAPTER XII.

SHAFTS.

Shafts—A shaft in machinery is a revolving member which transmits power. Shafts are of different types to suit the different conditions under which they work. The shafting in a machine shop affords a good example of the simplest form. A shaft used for this purpose consists of a long length of plain cylindrical steel upon which pulleys are mounted which drive the machines, or other shafts, by means of belts. The principal shafts used in motor-car construction are as follows:

Camshaft—A revolving shaft carrying cams. In the case of motor cars the term is applied to the half-speed or two-to-one shaft which carries the cams operating the valves or low tension magneto mechanism for breaking contact.

In a typical camshaft for a four-cylinder engine the shaft is turned, with its cams and collars, from one solid piece of steel, all the bearing and wearing surfaces being ground true after the shaft is hardened. There is a tapered end, to which is fitted any appliance which has to be driven by the cam shaft, such as the pump or fan. At the other end is the gear wheel, which is driven by a pinion on the engine shaft half its size, and so drives the camshaft at half the speed of the engine. On the inside of the gear wheel are two lugs, to which the governor balls are pivoted. Two collars solid with the shaft locate it in its bearings and prevent it moving endways. In the center of the shaft is a helical or skew gear wheel which drives a similar wheel on a vertical shaft, at the top of which is mounted the contact maker. The cams are eight in number, four of them operating the inlet valves and four the exhaust valves.

The reason for calling the camshaft a "half-speed shaft" is that the shaft is driven by means of gearing at half the speed of the crankshaft, as described under Internal Combustion Engine. That is to say, for every two revolutions of the crankshaft the camshaft only makes one. It is only necessary to operate each valve once during every two revolutions of the crankshaft, and this method of gearing is employed to lift the valve at the correct time. The camshaft is also used to vary the lift of the valves, or to give half compression in the cylinder head. In the case of low tension magneto ignition the contact breaker is operated by cams in the same manner. Also the ordinary contact maker or make-and-break device for high tension ignition is usually driven by the cam-shaft.

Cardan Shaft—Where two shafts are not in line with one another, or when their position in relation to one another varies, and one has to drive the other, an arrangement called an arbor or cardan shaft is used to connect the two. This shaft is fitted with universal joints at each end, so that it can adapt itself to the inequalities of the drive. Cardan shafts are also used to transmit power from the gear box to the rear live axle, and are then sometimes referred to as propeller shafts.

Countershaft—An intermediate shaft, taking power from one shaft and transmitting it to another by means of chains, gearing or belts. The term is usually applied to the shaft which crosses the car and carries the chain sprockets on its extreme ends, being driven by means of bevel wheels from the gear box. The term is also applied to the secondary or lay shaft in the gear box. Also called Jackshaft or Cross Shaft. See Secondary Shaft.

Crankshaft—The shaft which receives the impulses of the piston, the cranks converting the reciprocating motion of the pistons into rotary motion. The throw of the crankshaft is the distance between the center of the crankshaft and the center of the crank pin, this distance being, of course, half the stroke of the piston. The power from the crankshaft is usually transmitted to the gear-box via the clutch.

Cross Shaft—A shaft which transmits power from another shaft while its axis is at an angle to the axis of the shaft driving it. It is a term usually applied to the countershaft of a car.

Engine Shaft—See Crankshaft.

Flexible Shaft—A means of connection between two members capable of transmitting power from one to the other through any angle or angles whatever. It usually takes the form of a tubular spiral through the bore of which runs a flexible wire. The outer tube is fixed at each end, while the power is transmitted by the inner wire. It is used to a great extent in speedometers. A chain sometimes takes the place of the inner wire when the bends are not too acute. In the case of pumps, the spindle is sometimes driven by using a stiff spiral spring as a shaft between the pump spindle and the shaft driving it. In this case, should the pump itself jam for any reason, the spring will relieve the shock.

Gear Shaft—A gear shaft carries gear wheels or pinions which mesh with gear or pinion wheels carried on another shaft. In a gear-box, for instance, there are usually two gear shafts, one called the primary, being connected to the clutch and thus receiving its power from the engine, the other called the secondary, lay or countershaft, being connected to it by gear wheels and transmitting the power to the road wheels. See Change Speed Gear.

Half-speed Shaft—See Camshaft.

Hollow Shaft—Many crankshafts are now made hollow, as also are some other shafts, such as rocking shafts.

Intermediate Shaft—A term applied to any shaft which transmits power from one shaft to another either by means of belts or gears. The name is generally used in connection with the secondary gear shaft. (See Secondary Shaft.)

Jack Shaft—Same as Countershaft or Cross Shaft.

Lay Shaft—The same description applies to Lay Shaft as to Intermediate Shaft. See Secondary Shaft.

Motor Shaft—See Crankshaft.

Primary Shaft—The shaft in the gear-box which takes its power from the engine and transmits it to the secondary shaft. See Change Speed Gear.

Propeller Shaft—This is the shaft which transmits the power from the gear-box to the back live axle. It is provided with universal joints at either end, so that it can adapt itself to the varying angle between the gear-box and the axle due to the motion of the springs. See Secondary Shaft and Transmission.

Reversing Shaft—The small shaft in the gear-box which carries the reversing gear wheel; really an intermediate shaft.

Secondary Shaft—The shaft in the gear-box which transmits the power from the primary shaft to either the propeller or countershaft, or back to the primary shaft. See Transmission. It is sometimes called a lay shaft, countershaft, intermediate shaft, or gear-shaft.

Torsion Shaft—The shaft that runs through the center of a live axle transmitting the drive from the differential gear in the center of the axle to the road wheels. This shaft is really the "live" part of a live axle, the tube or axle proper through which it runs being used solely to support the springs on which the body rests.

Transverse Shaft—A shaft set at an angle to another shaft. The countershaft is a transverse shaft.

Two-to-one Shaft—Same as camshaft.

CHAPTER XIII.

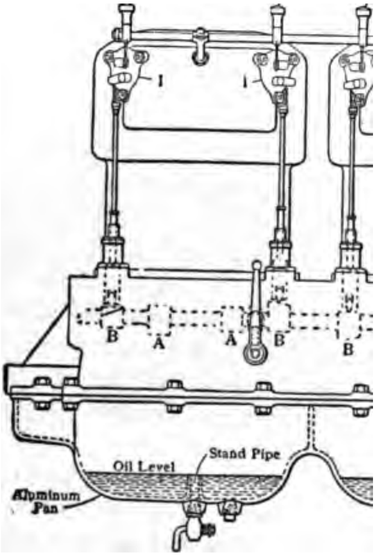
LUBRICATION AND LUBRICATORS.

Lubrication—In all classes of mechanism where two parts slide upon or move against each other, friction is set up which acts as a resistance to the movement, causing heat, and often spoiling the surface in contact. The object of lubrication is to separate the surfaces from each other by a fluid which must be of a greasy nature so that the surfaces, instead of sliding upon each other, displace the particles or molecules of which the lubricant is composed. These molecules can be likened to so many infinitely small balls.

The accompanying illustration ~~shows the method of lubri~~cation employed in a typical motor of the most modern construction. The splash system is employed in this case (see Lubricators) and a description of the modus operandi is as follows:

An aluminum casting containing two compartments with an intervening partition, is bolted to the motor base and carries a quantity of oil which is splashed about to the various working parts of the motor, lubricating them continuously and thoroughly. The partition prevents the oil from rushing to the front of the motor when descending a hill or vice versa. By consulting the diagram it will be noted that the level of oil is obtained by means of a vertical standpipe; a pet-cock at the base of the standpipe is opened and the oil is slowly added until the level rises to the top of the standpipe, and when it begins to drip no more oil is added and the pet-cock is left open until the drip ceases, and when it does, the oil level is correct and the pet-cock may be closed.

As the motor is run and the oil is slowly used to lubricate the wearing parts, the loss must be made up in order that the level may be maintained constantly; to do this a mechanical



Section of Motor, showing met

K K K K.	Cut-out
I I I I.	Igniters
B B B B.	Igniter c
A A A A	Valve ca

tales," so that the operator can assure himself that the lubricator is working properly.

The splash system of lubrication as employed in this typical case is very effective, and special provision is made so that the wrist pins receive a sufficiency of oil. This is accomplished as follows: A horizontal groove cut near the bottom of each cylinder is always kept full of oil which is splashed up from below, and when the piston reaches the bottom of the stroke, the oil which has collected in the groove enters the hollow ends of the wrist pin and works out to its bearing circumference by means of holes cut through the diameter. Every precaution is taken to insure thorough lubrication of the crank-pin bearings. Holes are drilled in the edges of the crank webs communicating with holes drilled through the crank-pins both transversely and longitudinally; thus, as the crank-shaft revolves, it collects oil which works through these passages to the crank-pin bearings, insuring thorough lubrication. The three main bearings of the crank-shaft are fed from oil pockets which collect oil splashed about by the crank-shaft; this same method of lubrication is also employed for the cam-shaft bearings, of which there are ten in number—five for the admission cam-shaft and five for the exhaust cam-shaft. The aluminum housing at the front of the motor containing the timing gears and the governor is supplied with a pipe leading from the mechanical lubricator to the case and thus engine oil may be fed in any desired quantity.

An engineer's oil-can with a long spout is carried under the bonnet where it is always ready for use. The base of the can rests on a bracket secured to the dashboard and a spring clip prevents the oil-can from rattling or working loose.

The Knox Lubricating System.

The Knox system of lubrication is the same as always used on all Knox 4-cylinder motors and is what is known as the French De Dion 1906 system, used on several of the highest class American cars and during the year 1908 adopted by several prominent foreign makers. This system is claimed to be the most reliable and economical used on motor cars, one exceptionally nice feature being the absence of odor or smoke at all times.

The camshaft near the rear end drives an upwardly projecting shaft for the ignition timer, and a downwardly projecting shaft for the oil pump. The lower portion of the crank case forms an oil reservoir from which, through a strainer, lubricant is drawn by the gear-driven pump previously referred to, and conveyed through passages formed in the crank case proper to the various rotating bearings of the crank and camshafts. In each connecting rod is drilled an oil passage, the opening of which registers once in every revolution with a similar opening in the crank pin, so that the wrist pin is not only lubricated by the oil distributed centrifugally, but by direct pressure through the connecting rod. The cylinders are amply lubricated by a mist of oil at all times present, the surplus oil falling back into the reservoir and, after straining, being again used. A pressure gauge attached to the dash registers the amount of pressure, which is varied at will by means of an adjustable spring by-pass.

Winter Treatment for Engines.

Force of circumstances occasionally compels the car to be laid on one side for a few weeks, and when this happens there are one or two points in the treatment of the motor which are well repaid—in more ways than one. A car that is driven straight into its quarters and left there for two weeks, or perhaps a month, deserves some slight consideration. In the first place it is an excellent plan to inject into the cylinder or cylinders, as the case may be, a small quantity of kerosene. It is obvious that what is good for one cylinder is, generally speaking, good for any number, so that unless it is specifically stated that a certain thing is only good for a certain engine, the matter may always be interpreted broadly. The reason for the use of kerosene is to clear the cylinder walls of lubricating oil, which is liable to oxidize, and so cause the piston to stick. Kerosene cleans the cylinder and piston, keeps the piston rings free, and still leaves a protecting coat of oil on the working parts.

While the cylinders are being cleansed with kerosene, the waste oil drain cock in the crank chamber should be opened, and the thick old oil run out. If the oil looks particularly dirty, it will do no harm to close the cocks and put into the crank chamber not less than a pint of kerosene. Give the starting handle a few vigorous turns, and then leave the engine for about ten minutes, at the end of which time open the drain cocks again. After using kerosene it is necessary to leave the drain cocks open for at least twenty-four hours, in order to clear away all the kerosene possible.

Expelling Dirty Oil from Crank Chamber.

A point that cannot be too strongly emphasized is the necessity for proper engine lubrication. A great many automobilists seldom give a thought to the matter of letting out the old oil from the crank chamber. It is a dirty job, so they just snap up their lubricator buttons, and allow the engine to go on as usual. The chamber wants a good flushing out with kerosene occasionally, for it should be remembered that dirty oil is charged with metal particles in a very finely-divided state, and consequently forms a first-class grinding medium.

Oiling the Clutch.

In many cars it is necessary to take up the floor boards for the purpose of oiling the clutch boss where it slides against the pressure of the clutch spring on the squared portion of the clutchshaft. Frequently, too, there is no lubricator fitted to the clutch boss, but merely a hole drilled therein, into which but little oil can be introduced, and that little is flung out again by centrifugal force as soon as the clutch starts revolving. For this reason this part of the mechanism requires very frequent attention in many cars, and this it does not get for the reasons given. We draw attention thereto because, unless some trouble is taken in this respect, the pedal work is apt to become laborious. Good machine lubricating oil should be squirted into this hole, and the clutch pedal worked vigorously up and down. The collar, too, in which the clutch-striking fork works in such systems must also be kept thoroughly well lubricated to insure easy clutching, declutching, and the saving of friction. Some means of automatically lubricating these parts should be fitted to all cars; but until such is the case, those whose driving economy is as we have sketched it must take up the floor boards and see to the matter.

Again, if the car owner will examine his flywheel, he may find a hole about three-sixteenths of an inch in diameter drilled through from the outside of the rim. This is for the purpose of introducing a softening agent to the surface of the clutch leather, when used, and very useful it is. Such convenient refinements are rare in the older cars, but the necessary treatment can thereby be afforded the clutch leather with much greater comfort than squirting whatever is used for the purpose through the narrow space between the two coned surfaces. The hole in the flywheel rim is also most useful for the introduction of gasolene to the leather of a slipping clutch. When applying either the oil or gasolene, the clutch should be held out just clear, and the engine turned round from time to time to get the dressing well distributed all over the leather.

Washing Out the Gear-Box.

After running a new car about 300 miles or so, it is advisable to drain all the lubricant out of the gear-box, wash the latter out well with kerosene, and, having allowed the gear-box to remain open and drain, to replenish with fresh lubricant.

Squeaks.

Failure of lubrication in any part of a motor and car is usually announced by a squeak, which may or may not be a matter of serious consequence. The automobilist should always endeavor to locate the squeak at the earliest possible moment, and the first point to note is whether the squeak appears to keep rhythm with the engine or with any portion of the gear, or whether it be an intermittent squeak without any particular period of frequency. One point is worthy of remark—that a sparking plug will occasionally develop a leakage round the wire or at the joint, which will give a squeak very similar to a squeak due to want of lubrication. Should this be suspected, the sparking plugs may be changed or new copper washers fitted.

Steering Joint Lubrication.

The question of lubrication of steering pivots has been rather a neglected one. Of late makers have been drilling the pins and inserting lubricators, but formerly the most usual method was to cover the pivots with a leather casing, and fill up with grease. Now if it is at any time necessary to remove the leather, there is the utmost difficulty in returning it. The reason is not hard to seek, for when putting the leather on, a piece is just twisted round the rod and arm and bound with wire. It is not difficult to arrange this differently, so that not only can the leather be taken off and put on, but so that it will make a tighter job and retain the grease better. The joints should be studded and the leather cut so that the flat piece of leather is a development of the parts which it has to cover; that is to say, when cut, it will resemble a T somewhat, the tail wrapping about the distance rod and the crosspiece folded over and inclosing the steering arm. Two thongs should be left cut diagonally from the junction of the tail with crosspiece, these thongs wrapping over and completing the case at the joint.

Lubricating Chains.

The only satisfactory manner in which driving chains can be lubricated is first of all to cleanse them thoroughly with kerosene, making sure that each roller of the chain is revolving freely on its rivet. Then place the chain, rolled up, into a shallow tin and put over it several lumps of good tallow which has been refined previously. The refining may be done by putting the tallow into a bucket of hot water and keeping it well stirred. All foreign matter will be precipitated, and, upon cooling, a cake of pure grease will be left on the top of the water. The tin containing the chain and tallow should then be put on the top of a stove which is only moderately warm. The chain will become heated slightly—not sufficient to alter its temper by softening, but enough to permit of the tallow being melted and finding its way into the spaces between the rollers and the rivets, where, obviously, it is required most. Some owners use a mixture of graphite with tallow, but graphite sinks to the bottom of the melted tallow, and, therefore, does not always do the duty that is expected of it. In order to prevent the collection of dust and dirt on the chain as much as possible, when the chain is removed from the tallow it should be hung up and all superfluous grease allowed to drain from it into the tin placed beneath. There will remain, of course, a thin film of grease over the surface of the chain, but no more than is sufficient to protect it in wet weather, though even this film of grease will collect dust. Practically, the only efficient way of properly lubricating a chain is to have it incased in an oil-retaining gear-case.

Drip Feed Adjustment.

A little item of great importance which is often overlooked has relation to the adjustment of drip lubricators. The practice is too common of leaving these appliances just as received from the makers, with the result that the frequency of the dripping varies in accordance with the viscosity of the oil used. A lubricator may be set to supply accurately a sufficient and not excessive quantity of one particular kind of oil, but when upon a tour some different brand of oil may be purchased which will not drip through the orifices of the lubricators with anything like the freedom of the oil for which the lubricators have been adjusted, with the result that the engine receives an inadequate supply; or an oil of a much lighter body may be purchased which will drip through so rapidly as to smother the sparking plugs and valves.

On Lubricating Oils.

In a number of motors, although the compression is good, power is not developed in accordance with the size of the cylinders, and there appears to be a decided tendency to overheat in the engine. This is often due to using a lubricating oil that is not suitable for the type of engine, as it is found that an oil which gives good results with one type is worthless with another. An oil may appear thick, and yet under the heat and working conditions may thin out to such an extent as altogether to lose its lubricating quality. If this is experienced with water-cooled motors, a good brand of oil usually employed for air-cooled motors should be tried. The results will be found to give satisfaction in most cases.

Heavier Lubricating Oil for Summer.

Each summer complaints are heard as to overheating of engines. In a number of cases this is no doubt largely due to the employment of the wrong kind of lubricating oil for summer use. For water-cooled motors it is not a bad plan in such cases to use oil recommended for air-cooled motors, as this oil is much thinner in summer when in use, and consequently becomes about the right consistency for the proper amount of feed during the summer months. Of course, as the weather becomes colder the usual brand of lubricating oil should again be used.

Over-lubrication.

When a thick cloud of blue pungent smoke is ejected from the muffler it is a sign that there is too much oil in the engine. While it must be admitted that this is good for many engines, especially when new, it must not be forgotten that such an emission is highly objectionable to everybody but those in the car. A simple and effective method of correcting this trouble is to open the compression cocks, when such are fitted, one by one. This quickly clears the cylinder, and with a surprisingly small amount of attendant mess when there is a clear way for the ejected oil. With a single-cylinder engine it is, of course, necessary to give the piston the necessary movement by hand. It is a somewhat extraordinary thing, but many engines will run with quite an overdose of oil without trouble, while others have a very decided objection to a too liberal supply of lubricant. For instance, a Daimler car requires but amount of oil, while, on the other hand, a Mercedes gloats on a full charge. Many makers adopt the ex- of fitting an overflow pipe in the bottom of the crank to prevent the engine getting more than is good for it.

Take Nothing for Granted.

ng should be taken for granted in the lubrication of an ile. Everything should be done to make the work ation as easy as possible by having every convenience The plugs and cocks designed for the drawing off ent oil from crank cases should be looked after care- see that they cannot work loose while running. If e amount of oil drips from any particular point of the it may indicate either that the supply is excessive, ans for retaining it are not proper or that the oil in. Thick oil, on the whole, gives little trouble from out of bearings, especially when everything is worn. aning down of a car is a duty which no one having incts of a mechanic will shirk, as the dust which an f oil on the outside surfaces of the wearing parts is solutely rusted solid in its place, and could not be moved at all; thus the rear brakes were rendered quite useless through simple neglect of fitting clips and oiling the parts regularly.

Kerosene Pump Lubricator.

If your car is unprovided with means by which kerosene can be injected into the cylinder, and the latter is not fitted with a compression cock, have a kerosene pump lubricator fitted to the dashboard with a delivery pipe, or, in the case of multiple cylinders, forked delivery pipes to the lubricating pipes, as close to the entrance of the latter to the cylinder as possible. The cylinder oil pipes must be provided with cocks just above the junction of the kerosene pipes, so that by turning off these before you do your kerosene pumping on coming in from your run, the latter oil is not forced back, as it may be, into the cylinder oil tank. Above all, do not forget to turn these added lubricating oil cocks on directly after you have flushed with kerosene. Forgetfulness in this particular may mean seizing, with all its horrors.

Cleaning Grease Pipes.

It is not often that grease pipes require clearing out, for which we ought to be duly thankful, for if the pipe be of any length, or contain complicated turns, then there are great possibilities of trouble. The best way to start is to pass a piece of stiff wire through the grease in the pipe, if possible, and if this may be done, then lay the pipe in a tray and keep it covered with gasolene. This treatment will soften the grease, and clear some of it out, so that the pipe may be charged with successive doses of gasolene and cleaned like a bottle. If one is lucky enough to have access to a steam boiler, then the pipe may be cleared by attaching it to the blow-off cock on the water gauge. It needs caution, however, when following this method of procedure, or scalded hands or worse may follow. The safer plan is most certainly that first outlined, but the latter is much quicker and cleaner.

For cleaning out the small pipes, a very good method is to use a pump made out of a bicycle tire inflater. this being pro-

for its differential and for its twc
of one inch in diameter, these hole
plugs. Now, to push sufficient g
orifices is a dirty and almost inte
overcame the difficulty by pressing
lubricator of the screw-down typ
gunmetal pot about four inches wi
the screw lid there is a piston wit
when the pot is filled with greas
turning the handle round. At the
a piece of copper tube eight or te
nothing easier than to insert this
then to screw down the lubricator, t
into the gear-box.

It may be interesting to add that
way to handle grease, when one is
a considerable quantity into the cha
use a small garden trowel kept espe
entirely free from grit. This is a ve
of dealing with 8 or 10 lbs. of gr
satisfactory than the ordinary way
on the end of a flat piece of wood

When taking over a new car, make certain that the grease lubricator has been filled and screwed down, and filled and screwed down again and again, until the grease is really serving on to the bearing, for in some cars the pipe leads from these lubricators are so long that several charges of the lubricator are necessary to fill the pipe before the grease really reaches the bearing. New bearings have seized or stuck before now for lack of this precaution.

It is often noticeable that the ordinary screw-down lubricator is very hard to manipulate. This is due to the feed-hole at the bottom of the lubricator being too small or to the lead pipe communicating with the bearings having too small a bore. There is no reason why screw-down lubricators should be made so difficult to operate; this matter really deserves more attention from the manufacturers and those who have to use them. The screw portion should be capable of being easily twisted round by means of the thumb and forefinger, and not have to be forced down with the hardest stress which can be put on with the hand or with a spanner.

Commutator Troubles.

Car owners whose high tension ignition systems include a rolling contact maker of the Lacoste type cannot be too careful about the lubrication of the commutator. When cars so fitted are first received from the makers, the interior of the commutator case will or should be found packed with a somewhat thin grease, with which the action of contact-making as the roller on the little arm passes over the brass or steel terminals appears to be as perfect as possible. After four or five hundred miles, the engine may be found to fire imperfectly on one or more cylinders, particularly when accelerated, and then such failures will frequently find their cure by the careful washing out of the commutator with gasolene, and, when the latter has dried off, the application of fresh grease. Care, however, should be taken as to the grease applied, for there are several very stiff kinds sold which, though good enough for bearings, are by no means suitable for commutator lubrication.

for this in some cars is rather cr
for lubrication is to undo a screw
of the differential casing—we are s
—and it is a long job to empty a
three or four syringefuls of oil can
time indeed. The pump can also
cleaning purposes, though, of cou
should be thoroughly cleaned with
used again for lubricating oil. T
for introducing grease into awkward
to do this is to put the grease in
pot, and place the vessel in a pa
grease will then be taken by the pu
oil. To prevent the fingers being b
a thick rag should be used as a p
pump has, as it should have, a cou
at the end of the barrel, as well as a

Lubricators for Sprin

Many cars, especially high pric
lubricators to each of the bearing
Lower priced

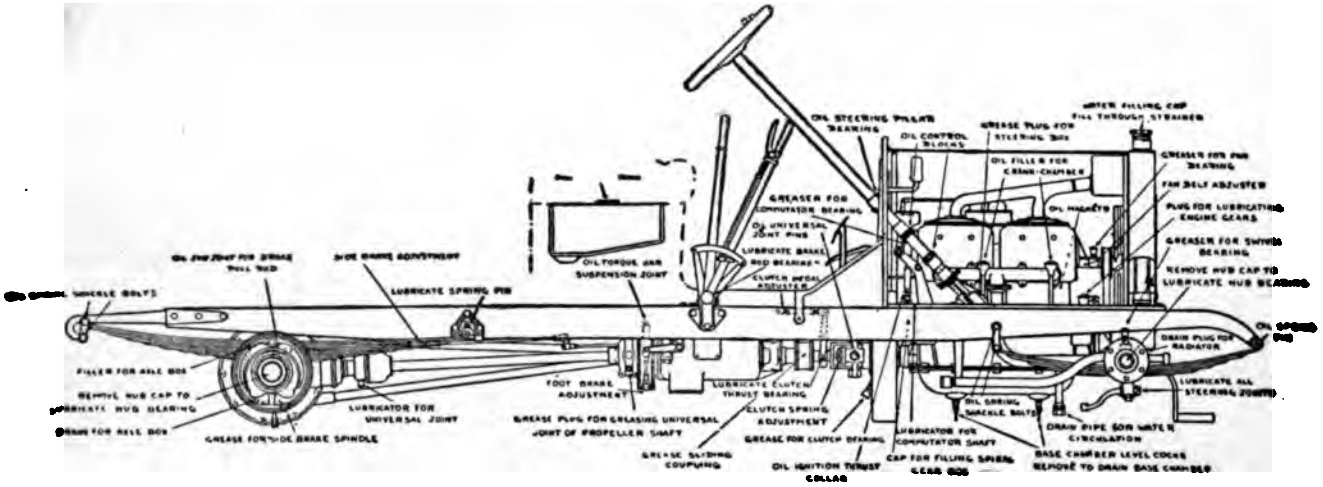
on bicycles. The types we refer to more particularly are the spring bands which are used on bicycle pedals. These can be obtained of different sizes, and can be sprung round the shackle bearings effectually to prevent dust getting in, and yet allow easy access to the holes when necessary.

Good Mufflers and Lubrication.

Where in some cars the muffler has been carefully studied to avoid back pressure, this may have been done so effectually that a very feeble pressure passes to the lubricator, and sometimes on a cold day no feed therefrom can be obtained. When this is so, there are two courses open: The first is to force some oil through the pipes, and that can be done by getting someone to put the sole of his shoe over the exhaust outlet, when the throttle can be opened; the engine will not race, as it will be slowed by choking the exhaust outlet. This will cause the oil to pour through the lubricator sight drip jets in fine style. The second procedure is slightly to warm the oil. This can be done by arranging a leak somewhere, so that the exhaust coming into the lubricator can pass right through for a time, and so gradually get some warm air through. If, however, the lubricator used to feed well, but becomes worse as time goes on, there is another thing to be looked for, and that is, that the oil, for some unexplained reason, has found its way into the oil pipe that connects the lubricator to the large exhaust pipe, and has become crusted up. This has been found the case with many cars under repair, and it is a thing one might look for indefinitely without finding it out.

The Smell from Cars.

There is no need for us to dwell upon the evils of over-lubrication so far as smoke and smell are concerned, but there are some cars which, whether they be over-lubricated or not, always smell more or less, and it will be found that this smell is different from the ordinary odor of burned lubricating oil. In most cases it is due to oil or grease leaking from the gear-box and thrown by the shaft on to the hot exhaust pipe. At this point the pipe may not be hot enough to


WATER FILLING CAP FILL THROUGH STRAINER
OIL STEERING PILLAR BEARING
OIL CONTROL BLOCKS
GREASE PLUG FOR STEERING BOX
OIL FILLER FOR CRANK-CHAMBER
GREASER FOR FAN BEARING
FAN BELT ADJUSTER
PLUG FOR LUBRICATING ENGINE GEARS
OIL MAGNETO
GREASER FOR SWIVEL BEARING
REMOVE HUB CAP TO LUBRICATE HUB BEARING
OIL SPRING PIN
DRAIN PLUG FOR RADIATOR
LUBRICATE ALL STEERING JOINTS
GREASER FOR COMMUTATOR BEARING
OIL UNIVERSAL JOINT PINS
LUBRICATE BRAKE ROD BEARINGS
CLUTCH PEDAL ADJUSTER
OIL TORQUE BAR SUSPENSION JOINT
OIL SPRING SHACKLE BOLTS
DRAIN PIPE FOR WATER CIRCULATION
LUBRICATOR FOR COMMUTATOR SHAFT
BASE CHAMBER LEVEL COCKS REMOVE TO DRAIN BASE CHAMBER
CAP FOR FILLING SPIRAL GEAR BOX
GREASE FOR CLUTCH BEARING
OIL IGNITION THRUST COLLAR
CLUTCH SPRING ADJUSTMENT
LUBRICATE CLUTCH THRUST BEARING
GREASE SLIDING COUPLING
FOOT BRAKE ADJUSTMENT
GREASE PLUG FOR GREASING UNIVERSAL JOINT OF PROPELLER SHAFT
SIDE BRAKE ADJUSTMENT
LUBRICATE SPRING PIN
OIL PIN JOINT FOR BRAKE PULL ROD
OIL SPRING SHACKLE BOLTS
FILLER FOR AXLE BOX
REMOVE HUB CAP TO LUBRICATE HUB BEARING
DRAIN FOR AXLE BOX
GREASE FOR SIDE BRAKE SPINDLE
LUBRICATOR FOR UNIVERSAL JOINT

LUBRICATION OF A TYPICAL MODERN CAR.

The motor is lubricated from a reservoir on the dash board fitted with sight feeds leading to the main bearings. The oil drips through these feeds, and must be adjusted to feed the right number of drops to each part. The crank should have 8 drops per minute, the connecting rods 10 drops per minute, the cylinders 10 drops per minute, the crank shaft 8 drops per minute. The oil in the base chamber should be maintained at the level of the overflow; it should be replenished and washed out and renewed occasionally. *Daily.*—When preparing a car for a run, one or two drops of oil are required at the following points—valve operating plungers and guides, control levers on steering column, accelerator shaft and joints of throttle levers, clutch on disengaging collar, pin joints of brake mechanism, pin joint of link of torque bar. Each grease lubricator one turn. *Weekly.*—The grease lubricators require filling every week in addition to giving one turn every day before using the car. They are applied to the various parts as follows:—Clutch bearing, universal joint between clutch and gear box, the two universal joints of the propeller shaft, the bearing of the fan spindle, the gear lever and quadrant, the swivels, and the levers and rods of the steering gear, the contact maker, the shaft of the internal expanding brakes, the wheels. The axle caps should be screwed off and filled with grease every two weeks. The box containing the worm and segment should be filled with thick oil or grease every three months through the cap provided. The gear box should be replenished with thick oil through the inspection cover on the top, as required, to keep it full up to one inch below the center of the gear shafts. The bevel gear which drives on to the back axle requires to be filled in the same way. The covers should be removed from all steering connections and re-packed with grease occasionally.

really burn the oil up immediately, but it gradually fries it, and makes a most unpleasant odor in so doing.

The remedy is a simple and obvious one. As a rule, the leakage, if round the primary shaft of the gear-box bearing, cannot be stopped, and the thing to do is to protect the exhaust pipe from the splashes. This can always be done by fitting a thin sheet iron shield an inch or two from the exhaust pipe and between it and the line of the oil splashes.

When driving slowly, too, it has been found that in many cases cars which have the muffler in front of the back axle are much more likely to emit unpleasant odors, of which the occupants of the car are unpleasantly conscious, than if the muffler is fitted further back. The muffler at the back with the final exhaust directed at a slight downward angle is less likely to cause inconvenience. Of course, it will be understood that the angle of the exhaust as it issues to the air will be only slightly downward. It will never beat upon the road, and if a line were taken from it to the road it would not touch the ground till it was at least ten or twelve feet behind the car, so that it has no disturbing effect upon the dust; in fact, if anything, it should tend to reduce dust raising.

LUBRICATORS.

Lubricators—These may be classed under two heads—gravity feed and forced feed.

Gravity Feed.

In gravity-feed lubricators the lubricant is placed in a chamber higher than the point at which it is to be applied, and by its own weight travels down to the oil squeezed from between the surfaces to be lubricated. Even where a simple oil cup is placed in a bearing it acts by gravity, the oil dropping down to replace that used up.

It is generally considered necessary to provide in this system of lubrication for some form of sight feed, so that ocular demonstrations may be obtained as to whether the oil is flowing or not.

Sight Feed or Drip Lubricators—Generally placed on the dashboard of the car, and immediately under the eye of the driver. The oil drops from the oil chamber through a needle valve, which can be regulated to allow it to pass the oil in the form of drops through a glass tube where the speed of the dropping can be easily seen, and the needle valve can be easily adjusted to cause the requisite number to fall in a given time. A number of these drips or sight feeds can be arranged from one oil reservoir, each one communicating by a pipe to the particular part of the car to be lubricated.

Forced Feed Lubricators.

In forced feed lubricators the oil is forced by a rotating or reciprocating pump, via small tubes, to each journal or bearing to be lubricated. It flows in a constant stream as long as the engine continues to run and to drive the pump. The oil flows over and around or through the bearing or sliding surfaces, and is collected in a drain chamber somewhere below the bearings, generally in a recess formed in the base of the crank case or gear-box for this purpose. It is from this chamber that the pump draws its supply, so that there is a constant circulation of the oil from the oil pump to each bearing and back to the oil pump again.

The feed of the oil from the tank may be either by gravity, as we have seen, or forced. In the latter case the tank may be placed in any convenient position on the car, and the oil is forced from it by air pressure in the tank itself. This air pressure may be obtained by means of a small hand pump, and a pressure gauge on the dashboard indicates to the driver if the requisite pressure is in the tank to keep the oil properly fed to the different bearings.

In another system the pressure of the exhaust gas is used to force the oil through the oil pipes to the various bearings. Part of the exhaust gases are passed through a non-return valve and filter into the oil reservoir, maintaining such pressure as may be required, a pressure relief valve being sometimes fitted to prevent the pressure in the tank rising above a predetermined amount. This system has the advantage of slightly raising the temperature of the oil, and this allows an oil of greater viscosity to be used.

In all cases the oil passes through sight feed lubricators on the dashboard, so that the driver may be assured that this important operation is going on properly. See Internal Combustion Engine.

Forced feed lubrication is also used in some cases on bearings which are fed with heavy grease. In a lubricator of this type the thick grease is contained in a cup which has in its top a plunger pressed down on the grease by a helical spring. As the grease is used up in the bearing and flows away, the spring plunger forces the thick grease down to take its place.

Pump Lubricators—The pump lubricator is almost always of the screw-down grease cup type.

Ring Lubricators.

These are now often used, especially in the bearings of engine crank shafts and the shafts of change speed gears. In this type the center part of the bearing is cut away, forming an annular chamber around the journal or shaft. In this chamber and around the shaft hangs a loose ring of larger dimensions than the shaft. The bottom part of this ring dips in an oil bath in the bottom of the annular chamber, and as the shaft revolves it revolves the ring hanging upon it, which carries around with it the oil from the oil bath, and deposits it over the shaft, from which it runs to the bearing parts at each side of the annular chamber.

Splash Lubrication.

This is used for lubricating the crank pins, gudgeon pins, and pistons of engines either independently or in connection with drip lubricators or force pumps. In this system the crank case is filled with lubricant to such a height as will allow of the cranks dipping into it at the bottom of each downward stroke. The oil is then splashed upward, and effectively lubricates the whole of the inside wearing parts of the engine. The oil, which is very thick before it is put into the crank case, but becomes thinner afterward on account of the rise in temperature which it there encounters, is forced into the crank case by means of a hand force-pump, generally situated on the dashboard, and provided with a cock, which communicates with the crank chamber, one or two strokes of the piston of this pump supplying oil for a determined number of miles running.

Graphite Lubrication.

A mixture of graphite or plumbago and grease is often used on the chains, chain wheels, and chain sprockets of chain-driven cars, especially in cases where such chains are not protected by efficient chain cases.

CHAPTER XIV.

PUMPS.

Pumps are used in both gasolene and steam cars. The pumps fitted to the latter are described further on in this article under "Steam Engine Pumps." The following types have been adopted in gasolene cars:

Centrifugal Pump—In this pump a number of curved blades fixed to a center boss are rotated in a closed chamber. The water is caught by the blades and forced upward to the discharge pipe.

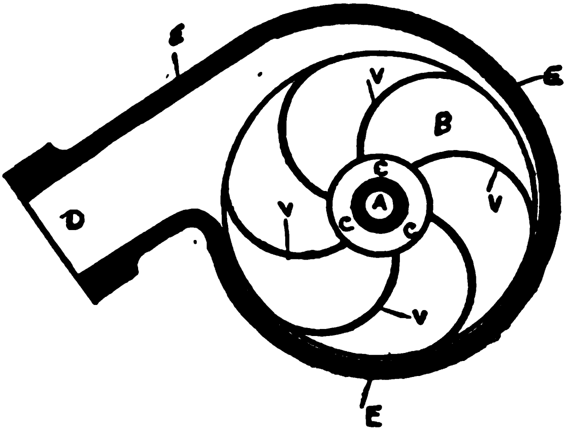


FIG 1—CENTRIFUGAL PUMP.

E E E, Pump casing.
C C C, Suction area at center of fan
B, Fan.
V V V V, Fan blades or vanes.
D, Delivery pipe.
A, Driving shaft.

The illustration shows a vertical section of a centrifugal pump. EE is the casing having the tangential delivery pipe at D. B is the fan of the pump having the curved vanes V, V, V, V cast with it. This fan is made with sides and is hollow in the center. It is mounted on a spindle A, which is rotated at a high rate of speed from the engine either by friction disk or gear wheels. The water enters the center C of the fan, and is ejected from the periphery by centrifugal force along the pipe D, whence it is conducted to the water jacket of the motor. Pumps of this description are reliable, and are widely used for circulation purposes.

The arrangement of the pump and the method of driving it are of considerable importance. The earlier types of centrifugal pumps were arranged to be swiveled on a hinge or joint; they had a friction wheel with a leather periphery, and this friction wheel was kept in engagement with the rim of the flywheel by means of a spring. So long as oil, wet, and dirt could be kept away from the flywheel this pump acted fairly well, but the leather wore and the spring lost its strength, and often the pump slipped and flats were worn on the leather, with the result that sometimes the pump would remain out of operation for a considerable time. Modern pumps are generally geared direct to the engine, and, to prevent trouble through their freezing, or anything jamming the pump, they are fitted with some form of joint which will easily give way so as to prevent injury to the engine, or to the vital parts of the pump. They are also generally arranged so as to be easily detachable for the purposes of examination and adjustment.

In a typical modern method of attaching the pump to the engine, an extension of the crank-case forms a bracket of semi-circular section, and to this bracket the pump is attached by means of a second bracket, also of semi-circular section. When bolted together the two form a kind of half case, in which will collect any water or oil which might leak through. The pump is connected to a camshaft by means of an Oldham joint, a form of the universal joint. A big hexagon nut secures the packing in the stuffing-box. At the top of the pump is the screw-down grease lubricator, and at the bottom is a draincock, by means of which the water can be drawn off when leaving the car in cold weather. This arrangement of the pump necessitates only one water-tight joint, and it has this advantage also that the front plate which carries the inlet can be easily removed by undoing the hexagon screws that hold its flange in position.

Propeller Pump—A type of pump which has lately come into considerable vogue is the combined centrifugal and propeller pump. In these the vanes of the pump are so arranged that they not only throw the water out by centrifugal action, but act also as a kind of screw, much in the same way as a screw propeller, and push the water along from the inlet to the outlet of the pump.

A good example of this type of pump has the pump casing with the water inlet concentric with it. The water outlet is at one side of the pump chamber. A cover which fits on the flat face of the pump chamber carries a bearing in which is mounted the propeller shaft. On this is the propeller blade, which approximately fits the inside surface of the pump chamber. The shape of the propeller blade is such that water entering at the inlet is forced along by the wings of the propeller both forward and outward, and flows through the outlet, partly by centrifugal action, and partly by the pushing action of the propeller blades. The advantage of both these types of pumps—that is, both the propeller and the centrifugal—is that should anything become jammed or the connection between the pump and its driving power fail, the water may flow through past the blades by thermo-syphonic action, thus to a great extent preventing overheating from pump failures.

Rotary or Gear Pump—Among the direct-acting pumps, that is to say, pumps which actually drive the water in known quantities for each revolution, we have one or two of the rotary type. These are generally known as "Gear Pumps," because they consist of two rotated members gearing with one another always, exactly as two pinions mesh together. These rotate in a closed chamber which exactly fits their sides, and whose outside walls are arranged close to their periphery, so that there is practically no space for the water to pass round them. They are very positive in their action,

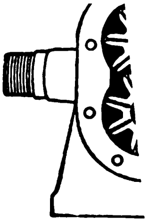


FIG.
THE ALBANY

In Fig. 2 a form of this pum
its class, with the exception th
ingenious method has been ado
be called a water-tight joint be
and the inner side of the chamb
each vane or tooth has a narr
radially, with a rather wider o
the pump is rotated at a high
water which lies in this slot is
centrifugal action, and forms a v
vanes and the chamber walls.

Steam Engin

Stea

so that when the steam is turned on from the boiler, the valves work automatically, admitting and exhausting steam to and from the engine, which being thus set in motion moves the plunger of the pump backward and forward. As these pumps are independent of the engine driving the car, there is no necessity for the latter to be set in motion to fill up the boiler, etc.

Plunger Pump—This consists of a piston working in a cylinder. Two valves are fitted—one at its mouth. When the pump is operated water is drawn in by the suction of the piston and cannot return. The second valve may be a non-return one, either in the piston itself (in which case the liquid passes through the valve as the piston moves, and during the next stroke is forced by the piston into the required pipe, or the second valve may be placed in the entrance of the discharge pipe, in which case, after the liquid is drawn by the piston into the cylinder, the next stroke forces it through the valve in the discharge pipe against any opposing pressure. The valve then returns to its seat and prevents the liquid returning. This pump may be either worked by hand or connected with the engine, and is principally used in steam cars to supply the boiler.

Hand Feed Pump—The hand pump on a steam car for supplying water to the boiler when there is no steam, or not sufficient steam to operate the steam pump, or where the steam pump has become inoperative.

Double-acting Pump—A pump which draws in and forces out the water or air on both the outward and inward stroke of the piston or plunger.

Force Pump—See Plunger Pump.

Other Pumps.

Air Pump—Otherwise Pressure Pump, and sometimes made in the form of a hand pump. Used for pressure feed in gasolene engines. A pump operated by the engine to supply air pressure to the oil or gasolene tank where pressure feed is used and where the gasolene tank is located at a lower level than the carbureter.

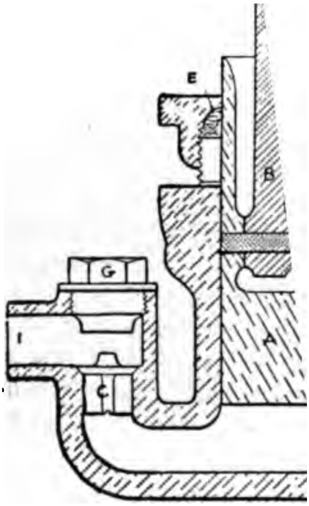


FIG. 3—PLUNGE

the ram causes the liquid to be
valve C into the boiler

cant to the bearings, under force. It may be either of the gear or rotary type, or of the plunger type, but is seldom of the centrifugal type.

Piston Pump—A pump in which the pumping is effected by a piston in a cylinder as distinguished from a centrifugal or a rotary gear pump. Sometimes called a Suction Pump.

Pressure Pump—See Air Pump.

Two-way Pump—A suction pump of the plunger type which has no automatic valves. It consists of a cylinder with a piston inside it, the piston being pulled up and pushed down by hand. The bottom of the pump communicates by means of a two-way cock to the oil tank and to the part to be lubricated. When the cock is turned so as to put the pump cylinder into communication with the oil tank, the plunger or piston is pulled up and oil flows into the pump barrel. The cock is then turned so as to put the pump into communication with the part where the oil is required, and the plunger, being depressed, forces the oil to the place requiring it. It will be seen that it not only acts as a pump, but also as a measure, as the operator can give a whole pump full, or half a pump full, or any quantity he deems requisite. In the case of some cars a compound valve is used, operated by the the handle of the pump itself; an indicator on the top of the pump shows in which direction the oil will be directed so that it can be forced to the crank case, the gear box, or the differential, as required.

Tire Pump—The ordinary air pump for inflating tires. Care should be taken to lay in a stock of "adapters" in case it is found that the nozzle of the pump does not fit the air valve of the inner tube. In this case the adapter has to be used, one end screwing on to the valve, the other into the nozzle of the pump. The necessity for these "adapters" is due to the fact that all pump nozzles and tire valve connections are not interchangeable.

CHAPTER XV.

MOTOR MISFIRING.

Missing Explosions—Whatever the cause, when a motor misses on one or more cylinders the trouble should be located and eliminated with haste. The owner of a four or six-cylinder motor is apt to overlook the fact that missing is occurring or to let it go, with the idea that the trouble will remedy itself. Where the missing occurs because of too heavy a mixture this can be accomplished at increased speed, so as to use up the surplus of gas; but where the cause lies in another direction it is a safe plan to stop and take a little time to do away with the trouble. Prolonged missing may play havoc with the bearings, connecting rods or some other vital part of the motor; it may cause a rupture in the gears and certainly is not pleasant to the occupants of the car.

When a motor begins missing explosions, where before it has been running with regularity, the trouble can as a rule be traced to the ignition system and it is but natural this should be the first to receive attention at the hand of the operator. Even when all things seem to be in perfect working order a motor will continue to miss and it is often a puzzle to locate the trouble. As an instance, a motor that had been running perfectly right along had been put in a repair shop to have a new piece of hose attached to the water system. The priming cocks were so made as to appear to be open when shut—and vice versa. A shop hand, seeing the cocks apparently open, endeavored to close but in reality opened them. Naturally this was overlooked. The motor started readily, but missed except at high speeds, when it could obtain sufficient gas. Two well-versed men worked on that motor for hours before the difficulty was detected and there was not a thing from carbureter to plugs that was not gone over from one end to the other.

It is a pretty safe rule that if the ignition system is found to be in good order, the attention of the operator should be turned to the carbureter and in all likelihood the trouble will be located there. Still, there are other reasons for a motor missing and they can usually be found in time.

Ignition.

(a) Plugs Fouled or Short-Circuited—When a motor misses, determine which cylinder is at fault by holding down the vibrators of the coil, one or two at a time, so as to cut out some of the cylinders. When the cylinder that is at fault is determined, look to the plug and see if it is fouled or covered with oil or if the porcelain is cracked. If after cleaning it appears to be good, attach the secondary wire, lay the plug on the motor to form a ground and turn the motor over until that cylinder is in contact and a spark shows at the points of the plug. If the spark appears good—that is, purple and reasonably large—replace the plug in the cylinder and run the motor. If the missing still occurs, replace the plug with a new one and try the motor again.

(b) Wire Off—Trace the entire wiring system to see if a terminal is broken, if a connection is loose, if a wire is off at the plug, commutator, coil, battery or magneto, and if the switch is clean and giving a good contact. See that the connections are clean and the binding screws are set down tightly.

(c) Broken Wire—On old cars in particular, the wire within the insulated covering is apt to be broken through twisting or excessive vibration. A broken inside wire in the secondary system will not cause missing; this will occur only in the primary circuit. It is a difficult thing to discover, as when the motor is running without load the ends of the wire are

points to not only make a
excessive flow of current. T
should be sufficient to cause
but should not be so severe as
adjustment of coils is treated
be referred to.

(e) Switch Loose—A loose
contact. It may cause missing
means of stopping the motor e

(f) Weak Battery—A weak
ing and even running, particul
be just right for the size of th
falling off in power—will becon
ceeds, although after the moto
car is under way fairly good
motor, however, will not resp
choke if the mixture is at all to
sets of dry cells, connect them
relief. If there are two storage
they can be connected in parall
an ammeter if dry cells are used.
from 15 to 17

(h) Pitted Vibrator Points—If the points on the vibrator spring or adjusting screw have been neglected for a long time they will be found to have become pitted; or there will be a little hole in one side and a little projection on the other, caused by the action of the current in passing from one side to the other. Where this has occurred the battery wires should be transposed, either at the coil or at the battery, the latter being more simple. It will take some time for the metal projection to leave that side and go back to the side whence it came. It is more than likely this condition will result in the vibrator sticking, and in this case it is advisable to square up the contact points with a very fine file or stone.

(i) Broken Vibrator; Vibrator Point Missing—A vibrator will not work in a satisfactory manner if the spring is either too weak or too strong; if the spring is broken or bent; or if the points have become very badly worn or lost. When any one or more of the conditions are found to exist the simplest remedy is found in new parts, although in an emergency a vibrator spring can be straightened and made to do service. If the platinum point is lost a new point can be made from german silver, iron wire, a piece of silver from a dime or almost any soft metal, even copper. A little piece can be riveted to the vibrator so as to permit the motorist to lose little time on the road.

(j) Condenser Perforated—It is not often this occurs. It may result from a battery being used whose voltage is much higher than is intended for the coil. This can be determined by a test made with a galvanometer and should be made by a coil maker or coil repairer. Where a multiple coil is used and one cylinder gives trouble, the units can be changed about to determine whether the coil is at fault. If, after changing the units, the same cylinder gives trouble the difficulty cannot be charged to the coil but to the plug, timer, or some other part closely allied to the particular cylinder giving trouble.

(k) Coil or Magneto Wet—If the coil or magneto has been exposed to rain, either may have become short-circuited. This will not only cause missing but, where batteries are used, the

wax or paraffin and destr
spark coil becomes wet, it is ad
to be repaired.

(l) Wires Wet—Where wir
—are run under the frame of th
water thrown by the wheels, a
cuit is apt to result and cause co
or a case of violent missing. W
manner the operator is advised
trouble on the road by protecting
as encasing them in hose.

(m) Ground at the Timer—In
wire at the timer has been remo
has become worn, one strand of
arated from the others and touch s
ing a short circuit. This is a com
where modern terminals are not
has been broken off. One or m
timer or other part, forming a gro
at all times and therefore will ca
mittent. See that the primary wir
clear of all metal and that the ins
binding posts. It is a good plan t
This will

from passing through the circuit. This can frequently be detected by the motor running well after the plugs have been cleaned and missing as soon as they have become fouled. It is possible to raise the points slightly so as to make the contact longer when the roller passes over them. Care must be used, however, to see that the points are not raised so far as to cause an edge to be felt when the finger is run around the path of the roller on the fiber lining. If a contact piece does become worn, the timer can be taken to a machine shop and turned down on the inside sufficiently to cause the inside surface to be perfectly even.

Carbureter—Mixture.

(a) Mixture Too Lean—Missing, particularly at high motor speed, when the motor is running idle, is generally caused by a lack of gasolene or surplus of air, and is accompanied by a popping back in the carbureter. This is where the float level is correct. If the float level is too low, the same effect will be noticeable. Either a little more gasolene through the medium of the needle valve or a trifle less air will generally effect a cure. See Adjustments, under Carbureters.

(b) Mixture Too Rich—Too much gasolene or too little air will cause the motor to miss, to be sluggish, to cause the car to jerk and to pick up slowly. It will also overheat the motor. At high speed this will not be so noticeable, as the motor will use the excess. To determine this, throw out the clutch and race the motor. If it runs evenly under such conditions, it is strong evidence that the mixture is too rich and the carbureter should be readjusted. See Adjusting Carbureters, under Carbureter.

(c) Air Leak in Manifold—If the nuts or bolts holding the intake manifold to the motor become loosened and permit a slight leak of air, the motor will be hard to start and will miss badly except possibly at high motor speed, in which case there will be a sufficient charge of gas taken into the cylinder. Where an air leak is the trouble the motor will not throttle well and will not develop power under heavy work. If tightening the nuts or bolts does not effect a remedy, a gasket of some thin material, or even shellac, will be required.

(d) Priming Cocks Open—Symptoms the same as in the case above cited. The motor will be hard to start and the motor speed under no load will be excessive. The running of the motor will be accompanied by a hissing sound, caused by the inrush of air.

(e) Restricted Gas Supply—Where the throttle is so set as to restrict the supply of gas, the motor will miss—sometimes only occasionally, according to the supply of gas. The throttle should be so set as to permit the motor to run regularly. If it runs at excessive speed, the mixture is at fault and should be adjusted.

(f) Cold Motor—No matter what the nature of the mixture, a motor will miss when excessively cold and continue to do so until it has become heated. Gasolene will not volatilize readily when cold, and propagation of the gases is slow. Where the motor is cold, also, there will be a firing in the carbureter, because of slow combustion. When the motor is cold and missing takes place, the ignition can be advanced considerably past the normal point until the motor has become warmed.

(g) Valve Spring Weak or Broken—When a valve spring is too weak to permit the valve to seat, or is broken, causing the same trouble, the motor will naturally miss because of its inability to hold gas in the particular cylinder having the troublesome spring. If the valve spring is broken, an iron washer may be placed between the broken ends—and over the valve stem, of course—and the motor will run as well as ever. Care must be exercised to prevent the washer from binding at any point. Where the spring is excessively weak, washers may be used to place a tension on the valve spring.

(h) Valve Stem Bent—A bent valve stem will cause the valve to stick and hold open, permitting loss of compression and preventing suction of gas. The valve must be taken out and the stem straightened. In an emergency this can be done on the road, although it is a mechanic's work. In case of a roadside job, the stem should be laid on a piece of wood which is slightly concave. Another piece of wood should be interposed between the stem and hammer, otherwise the stem will be so marred as to be unable to pass through the valve stem guide. The blows to straighten should be light, followed by close inspection. When the stem will work freely in the guide, and the valve seats, it can be used. Straightening a stem is apt to unseat the valve and this may need regrinding.

(i) Valve Stem Sticking—A valve stem may stick from being fouled with carbon or gummed with oil, in which case all that is necessary is to clean carefully with kerosene and gasolene. Do not oil valve stems.

(j) Valve Not Seating—This is not usually a cause for a motor missing. It will interfere with obtaining a correct carbureter adjustment, however, and a poor carbureter adjustment will cause a motor to miss, so that indirectly it may be the cause of the trouble. The remedy for this is to regrind the valve until it seats perfectly.

CHAPTER XVI.

NOISES IN THE MOTOR.

Pounding and Knocking—It is not always easy to distinguish between these two terms—"pounding" and "knocking" —in connection with a motor. A pound may be described as a deep-toned, muffled sound, while a knock is sharp and is accompanied by more or less of a metallic ring. The presence of either calls for immediate investigation and elimination, as to be permitted to continue might—and undoubtedly would —cause almost irreparable damage or damage that could be rectified only at considerable financial expense and the laying up of the car for a few days.

Pounding.

(a) Loose Connecting Rod—Remove bottom half of crank case or side plates, according to motor design, and feel connecting rod and crankshaft bearing for looseness. If there are shims between rod and cap, remove one or more so as to bring the cap close against the shaft. This will effect a temporary repair, but as soon as possible the connecting rod and cap should be scraped to insure a good fit. Do not fit the parts so close as to cause them to bind; a little play will be better. When replacing, rub on plenty of lubricating oil; never assemble wearing parts dry.

(b) Loose Bearing—Usually the back bearing. A loose bearing is hard to locate and is usually found through the process of elimination. A piece of ¼-inch steel wire, one end placed between the teeth and the other over the bearing will usually locate the trouble while the motor is running. If the pound is bad, have the trouble eliminated at a good repair shop. Such trouble develops slowly and seldom prevents one from continuing on a journey of reasonable length. Where a bearing is loose the noise is more noticeable at slow motor speeds. In cases of this kind run the motor moderately.

(c) Loose Flywheel—Particularly common where the flywheel is keyed to the crankshaft and not easy to determine. More apt to show when motor is running idle than when clutch is engaged. Where flywheel is bolted to a flange made integral with crankshaft, tighten nuts on bolt ends; where keyed on, drive in key, using soft iron or brass bar between key and hammer.

(d) Preignition—Carbon in cylinders, which keeps aglow from heat of the explosion, will ignite the incoming gas before the piston has passed the top of the compression stroke. This tends to drive the piston downward and against the momentum of the flywheel, thus causing a pound. It tends to spring the crankshaft and wear the bearings. The use of kerosene or carbon remover may remove the trouble to some degree temporarily, but the surest way is to take the carbon out through the valve cage holes in valve-in-the-head motors or by removing the cylinders in other types. Excessive lubrication causes carbon deposits.

(e) Shaft Sprung—A loose bearing, preignition or advanced spark may cause a crankshaft to spring slightly out of true. It can be determined only by removing the cylinders and top half of the crank case and revolving the crankshaft and testing with a surface gauge to determine trueness. To remedy such a disturbance requires the work of a thorough mechanic; better still, send it to the factory which made the motor.

(f) Lost Motion—Looseness in any of the working parts will cause a pound and can be located only by patient search and through the process of elimination.

(g) Misfiring—One or more cylinders misfiring will cause a decided pound. Locate the cylinder and stop the missing. See chapter devoted to missing.

(h) Unequal Compression—One cylinder with compression weaker (or greater) than the other will cause a pound through being out of balance. Try each cylinder for compression and endeavor—through grinding values, tightening plugs and valve caps—to bring all to an equality.

(i) Restricted Exhaust—A motor which has been overlubricated and permitted to smoke, will foul the exhaust pipe and muffler, causing decided back pressure and creating a pound. If there is a muffler cut-out, open this to determine if the trouble lies here. Clean the muffler by dissembling, if possible, or by soaking in kerosene for several hours. Be careful that all traces of kerosene are gone before assembling and starting the motor. The kerosene may be washed out with gasolene, and should be left to stand over night so the oils will drain out.

(j) Loose Wristpin—Possible but not likely cause. Determined by disconnecting the connecting rod from the crankshaft and moving up and down. If loose, new wristpin bushings in the cylinder constitute the remedy.

(k) Connecting Rod End Slap—Most makers provide for about ⅛-inch end play on the crankshaft end of the connecting rod. Occasionally the bearing becomes rounded, so that on the impulse stroke the rod slips on the crankshaft and causes a slap on the end. It is disagreeable and indicates that the bearing needs attention. It is likely to accompany a loose connecting rod bearing and can be determined in the same manner. Removing shims, however, will not remedy the matter; the bearings, if rounded, must be scraped until they are square with the crankshaft.

(l) Loose Cylinder—Place the hand so as to cover the base of the cylinder and part of top half of the crank case. If loose will be felt. Set down nuts holding cylinder to base. Do this occasionally as a good rule to follow on general principles.

(m) Loose Crank Case—May be loose where bolted to frame; bottom half may be loose. Either determined by examination and holding hand on parts when motor is running. Tighten nuts to remedy.

(n) Nut or Bolt in Crank Case—A nut might loosen, drop to the bottom of the crank case and the connecting rod hit but pass same. This is unlikely, as in all probability striking it would break the case instantly.

Knocking.

(a) Spark Advanced—This causes the gas to ignite before the piston has reached the top of the compression stroke—it is preignition and causes a decided knock. Particularly noticeable if motor speed is slow, as in ascending a grade, and spark has not been retarded. Will cause bearings to wear. Spark should be kept in close relation to speed of the motor.

(b) Overheating—Lack of water passing through the water jackets causes the metal to expand and bind the reciprocating parts. Water supply may be short or not circulating. Excessive use of oil might permit a short run only.

(c) Lack of Oil—Very common cause for knocking. Motor will bind if stopped. In this case work a small quantity of kerosene into the cylinders through plug holes and turn motor by hand. Then work in lubricating oil in small quantities until motor is free. See that crank case has oil and that lubricator is working.

(d) Piston Ring Stuck—Caused by over-lubrication and consequent carbon deposits under rings. Remove plugs, inject two tablespoonfuls kerosene in each cylinder, permit it to stand over night, turn motor vigorously by hand—with plugs removed—to eject surplus kerosene.

(e) Preignition—Also causes knock. See under head of Pounding, above.

(f) Push Rod Clearance—Ends of valve stems and push rods—and rocker arms in valve-in-head motors—will wear, causing too much clearance and a knock. Clearance should be adjusted according to maker's instructions. If too close or too far apart, the time of opening and closing the valves is materially affected.

(g) Timer Slipped—Occasionally the commutator will slip and thereby automatically advance the spark. Thus the necessity for knowing where the timer should be set on the cam shaft. Usually, of course, the tendency is to retard the spark where the timer has slipped.

(h) Loose Cam or Cam Shaft—Loose cams are unusual now, as cams are cut integral with the camshaft. Shaft where keyed to gear may be loose, or gears may be worn to cause slight knock. Not likely. If key is loose, drive in; if gears are worn, replace, as much play affects the time of valve action and ignition.

(i) Loose Pump or Magneto Pin—Pump shafts are frequently driven by a pin; magnetos are thus driven only occasionally. In pump, if packing gland is not tight, driving against pin if loose will cause very slight knock.

(j) Loose Magneto—Fastening of magneto may loosen and cause knock.

(k) Loose Oiler Mechanism—Where mechanical lubricator is driven by ratchet or eccentric mechanism, a worm or loose part will cause a knock, which can be removed only by taking up the wear.

(l) Fan Hitting—Bent fan blades may hit radiator; straighten. Set screw may strike belt; put in shorter one. Belt fastener may slap pulley; replace.

(m) Rocker Shaft Loose—In make-and-break ignition, rocker shaft or pawls may be deranged or loose or worn. Go over and tighten or replace.

CHAPTER XVII.

MOTOR OVERHEATING.

Overheating of the motor may result from a number of causes, which are taken up in the order of probable frequency. Here appears the necessity for knowing the maker's scheme of timing the spark and the setting of the valves, inasmuch as these points may enter into the cause of heating.

Modern motors are not prone to overheating troubles from lack of proper design; they will cause trouble if some adjustment becomes disarranged or the operator does not give some attention to this very important matter. Heating may be divided into several classes, but four will, when properly subdivided, cover the majority of cases. In case of an overheating motor, look for the trouble in the order given below:

Radiation.

Lack of Water—Examine the tank and fill with clean, strained water. Soft water is preferable. Run the motor to remove the air in the radiator and pipes and keep putting in water until filled.

Fan Not Working—(a) Belt lost—Make temporary belt from clothesline, sewing machine belt, wire spring if long one can be secured, or from shoe laces. After using for a while, see that stretch is taken up.

(b) Belt stretched—Take up slack by removing from one pulley and twisting, securing ends as originally.

(c) Belt coated with oil—Remove and wash with gasolene; for temporary job rub on fine sand, being careful that none finds access to the working parts of the motor or other wearing parts.

(d) Tightener slipped—Reset nut or set-screw; if either is broken, use a piece of wire to hold tightener, attaching wire to some part of the bonnet or motor.

Pump—(a) Pin through driving shaft sheared off—The pin can be replaced temporarily at least while on the road by a wire nail, piece of heavy wire, cotter pin or small bolt. Where this temporary repair has been made with a makeshift pin of soft metal a frequent examination should be made to see that the substitute is holding.

(b) Packing gland loose—If packing material has become lost, replace with a piece of candle wicking soaked in oil or grease. Strips from a handkerchief will do on a pinch. Replace the gland and screw up fairly tight. If the packing gland is loose it is apt to cause an air leak and prevent the pump from doing full duty.

(c) Gears worn—When the gears in a gear pump or the vanes in a vane pump become worn it means a repair shop job of turning down the plates so the sides will be brought closer to the gears. This trouble is not apt to develop suddenly or on the road unless on a long tour.

(d) Pump clogged—Some pumps are protected by a screen, which in time becomes clogged with pieces of rubber disintegrated from the hose or by sediment from the radiator. This will stop the circulation and should be removed.

Other Causes.

Radiator Fouled—Where water containing lime has been used a scale will form and if not removed frequently will cause severe overheating. It is well to clean the radiator three or four times a season on suspicion. A scale remover can be purchased, or a mild solution of lye can be used. Dissolve half a small can of lye in a pail of water, stirring until all is dissolved. Strain and pour in the radiator. Run the motor for a few moments. Let stand 10 minutes and drain off. Fill with clean water, run the motor and drain. Repeat the clean-water operation four or five times. Do not permit the lye water to touch paint or varnish, else the latter will be ruined. It must be remembered that the lye will sooner or later destroy the rubber hose, which must be renewed as occasion seems to demand.

Clogged Radiator—To determine whether the radiator is clogged, disconnect the lower pipe—the one running to the pump—and see if the water flows freely. If not, the radiator is clogged. To remedy this attach a hose and resort to slight pressure to remove the obstruction. If water pressure will not suffice, about 25 pounds of air or steam, the former preferred, will in all probability do the work.

Pipes Restricted—It is possible in replacing water pipes and using gaskets to restrict the circulation of water if the gaskets are misplaced a trifle. Placing gaskets should be done with care.

When replacing hose it is possible to ruffle the inside end with the edges of the metal pipes and to cause pieces of rubber to become dislodged. This should be avoided if the pipes are not to be clogged.

Imperfect Air Circulation—Where the fan is formed by webs in the flywheel the bonnet and pan under the motor must be practically airtight in order that the air may be pulled through the radiator and thus perform its duties of cooling. Holes in the pan or open joints in the radiator will prevent the proper circulation of air and should be stopped up in any manner possible.

Where a motor is so designed that proper vent for the crank case cannot be secured, heating may result; this is not apt to occur in modern motors, however.

Late Ignition.

(a) Timer slipped—Timers are frequently secured to the end of the camshaft or to a vertical shaft driven through bevel gears by the camshaft, by means of set screws. If there is a bind in the wearing parts of the timer and the set screw becomes loosened the shaft will slip away from the proper position and the spark will become retarded, causing overheating and non-responsiveness on the part of the motor.

(b) Gears misplaced—Where a vertical shaft carrying the timer is driven through bevel gears from the camshaft, it is possible in reassembling to misplace these gears one or two teeth and thus cause the ignition to be retarded and cause heating or to advance the ignition too much and cause a knock in the motor.

It is well to have the timer and the gears marked so they can be correctly replaced.

Carburation—Too rich a mixture will quickly cause overheating, and some good authorities claim that overheating can result from too lean a mixture, although the author has never known of a case. At any rate, it is just as well to have correct mixture as too lean or too rich. Too rich a mixture can be detected by the odor of unburned gasolene and by black smoke from the exhaust. Too lean a mixture can be detected usually by a popping back into the carbureter.

Additional Causes of Overheating.

Tight bearings or tight piston, resulting from either too close a fit or a lack of lubrication, will cause severe overheating as a result of a more liberal supply of gas to make the motor do its work. If it is found this is the trouble a superabundance of lubrication will probably effect a cure, although it may result in sooting the plugs and possibly carbonizing the cylinders.

If the exhaust pipe and muffler become more or less restricted as a result of carbon deposits arising from an excessive use of lubricating oil in the motor, it will cause a back pressure and consequently overheating if not a stopping of the motor. This can be determined by using a muffler cut-out, if one is fitted, to give perfectly free exit to the exhaust gases. Both muffler and exhaust pipe should be removed at the end of a season and thoroughly cleaned.

When the valves become disarranged through error in reassembling and the exhaust is not permitted to find its way out of the cylinder at the time designed, the prolonging of the time for holding the exhaust will cause overheating; thus the necessity for knowing the correct valve setting and having the valves set properly.

CHAPTER XVIII.

ELECTRIC MOTORS.

The electric car is the ideal motor car in certain respects, says an authoritative writer on the subject, and the less perfect in certain others. The chief defect is in the means of supplying energy to the motor. The chief perfection is in the means of applying the energy and controlling it which the motor itself affords.

The continuous torque, perfect balance and high speed of which the motor is capable diminish the stresses on the transmission chains or gear and effect an economy of weight by dispensing with flywheels, gear, etc., which is, however, not sufficient to counterbalance the excessive weight required by the storage cells if these are to have any length of life and to travel for distances comparable to the mileage of gasolene cars. Unlike the gasolene engine, the electric motor may be made to turn at a constant speed regardless of the gradient, or at will at an approximately constant rate of working no matter what speed, within limits. These qualities afford immense advantages which are unobtainable with the explosion engine, though they are reached to a certain extent with those steam engines which allow a variable cut-off. To enable the gasolene engine to work at full power while the car travels at a low speed, gear which is changed brusquely in steps is resorted to, and to enable the gasolene engine to work at a constant speed, no matter what may be the effort required by the road gradients, requires an efficient system of governing, and further makes it necessary that the engine shall be of such large dimensions as to be able to permanently give what may be only a momentary excess of load.

The electrical connections to the motor, controller and batteries of an electric car, though they require larger conductors than the electrical connections for the ignition of a gasolene car, are in most cases not appreciably more complicated and in many cases are more accessible. This means in practice that the electric car is, to a degree which is not always appreciated, simpler than the gasolene car, or, in other words, the ordinary gasolene car frequently carries in miniature the whole of the complication of the electric vehicle with an internal combustion engine and a gear-box in addition.

Turning from the perfections of the motor and passing to the difficulties which attend any attempt to make portable a supply of electric energy, we find a far less hopeful state of affairs.

The comparison between an electric car and the more usual type of motor car driven from an explosion engine may be briefly summarized as follows:

Advantages of the Electric Motor for Automobiles—1. A rotary engine of light weight giving a large torque at small speeds, able to stand overloads.

2. High internal efficiency of the combination of motor and its speed-reducing gear, if any.

3. A cheap mechanical equipment for speed control, owing to the possibility of dispensing with gear and clutch for change speeds.

4. Cheap maintenance, cheap lubrication, freedom from breakdown.

5. Absence of lubrication troubles, valve troubles, oil, dirt, smell, water-circulating troubles, pumps, cooling radiators, pipes, inflammable material in store, etc.

6. Extreme simplicity—three parts only; motor, controller and battery; ease of finding faults, and ease of measuring power used.

7. Cheap and clean housing; no fire risk compared to gasolene risks.

8. Ease of manipulation; flexibility of control owing to the absence of mechanical links, bell cranks, etc., allowing controller to be placed anywhere regardless of position of motor.

9. Thoroughness of control: reverse for all speeds, motor usable as brake, yet absorbing little power when driven by the road wheels when coasting.

10. No exhaust noises, backfire or muffler explosions.

11. Certainty and ease of starting from the driver's seat by a switch only.

Disadvantages—1. Weight of batteries, which more than counter-balance the advantage here gained on the motor.

2. Cost of battery, which outweighs the cheapness of the electric motor and the cheapness of mechanical equipment.

3. Inefficiency of battery, which outweighs the efficiency of the motor and absence of gear losses.

4. Rapid depreciation of battery, which outweighs the small cost of upkeep of motor, and economies due to having no clutches or gear.

5. Acid fumes and spillage, which may be set against the absence of smell and absence of oiling, and the depreciation by way of dirt which oil brings.

6. Loss of time for recharging, say one-quarter of the useful time.

7. Limited number of charging stations and distance possible on one charge.

8. Occasional necessity for losses in charging due to variety of pressure at different stations.

It will be noticed that the first among the disadvantages is the weight of batteries, and this, taken in conjunction with the volume they occupy, their liability to rapidly depreciate, and their small capacity from the point of view of the num-

batteries can be looked upon as c
expenditure, and the lack of succe
time troubled those who have inst
ice is very largely ascribable to t

Distance Traveled—The averag
up as a pleasure carriage for tow
when new, about 40 miles upon c
In practice, says the authority quot
with the loss of battery capacity w
occasional high discharge rates re
quent re-starting and stopping in
distance which may be covered day
is 30 miles, with the possibility of c
more. Any attempt to largely inc
many such attempts have been ma
advertisement of new batteries, etc.
so large an increase of the weight
portion of deadweight to useful weig
and the wear of the rubber tires ha
their cost of upkeep, or the battery
discharges in proportion to its capac
shortened and the cost of renewal
which is unsatisfactory in ordinary
effective

consumption of energy, say, to 90 watt-hours per ton-mile. But even if the usual route avoids all important gradients the consumption in town use may be taken as 100 watt-hours per ton-mile on an old and worn vehicle.

Weight—It has been for some time held that with batteries of the type now in general use, about one-third of the total weight of the loaded car should be batteries, the weight of battery being taken complete—that is, including all liquid, boxes, lugs and connections.

Method of Transmission—Almost all possible methods of transmission have been adopted in practice, for example: (1) The direct-coupled motor, in which the motor armature actually forms one piece with the front road wheel. Two motors are used, and the armatures are, by means of the controller, grouped in series or in parallel, according to the speed or torque required.

(2) The single reduction geared motor, in which two motors are used, one driving each front or each back wheel through one spur wheel and pinion; or

(3) The single reduction chain drive, in which one motor is used to drive a chain which passes over the middle element of the differential gear.

(4) The single reduction chain drive, in which one motor is used with the armature rotating in opposite direction to the field. The armature is connected by a chain to one back road wheel, and the field by a pinion and chain to the other road wheel, thus dispensing with the differential.

(5) The worm wheel drive, by which a single motor is placed in the front of the car, and drives a propeller shaft connected by means of a worm wheel to the middle element of the differential gear.

A feature which has unexpectedly turned out to be in favor of the electric automobile is its limited range of travel. This has the effect of obliging the owner to keep the vehicle in some town and there the inducement to him to contract for an inclusive annual sum for the maintenance of machinery, maintenance and painting of carriage work, maintenance of by unskilled attendants, has rende ment of any such maintenance sy out of the question, save for an a tically prohibitive.

This does not indicate that the run, for on the contrary it is appre mean that the very limitations of t tate supervision and the formulatio which many owners of cars prefer getting good drivers and the advan car in an emergency.

PRINCIPLES AND CO OF THE ELECTRI

Electric Motor—In construction t tically the same as the familiar d for a different purpose, and often u tion motor it can be started at once, and has the further advantage that it is self starting. As electric motors for traction work have been in use for many years, there was no necessity for motor car builders to design any special types for themselves, though many improvements have in fact been made.

Principle of the Motor

An electric motor is similar to a dynamo, but instead of converting motion into electricity, it converts electricity into motion. The motor consists of magnets and an armature, as in magneto ignition, but on a much larger scale. Further, the magnets are not permanent, but are excited by the passage of current through insulated wire wound upon them, the current being derived from the battery on the car. Magnets thus excited by an electric current are distinguished as electro-magnets. The faggoted core of an induction coil is another example of an electro-magnet. The magnets are arranged around the armature, and their ends are provided with pole pieces, curved to form a bore within which the armature can rotate freely but with very little clearance. There are generally four magnets, and the poles are arranged alternately, negative and positive. The cylindrical space inclosed by the poles is known as the magnetic field, and the magnets themselves are called the field magnets.

The armature core is laminated, and has a large number of radial grooves (not merely two, as in an H-section magneto armature), and each pair of grooves is wound with a separate coil of insulated wire. The ends of the respective wires are connected to a series of copper sectors, severally insulated from one another, and together forming a cylinder arranged concentrically around the armature spindle, at one end of the core. This cylinder is called the commutator.

The sections of the armature constitute a series of rotatable electro-magnets, and they are excited in turn by current passing from the battery through two carbon brushes bearing upon the commutator. As each armature magnet becomes excited, it is operated upon by the adjacent field magnet and caused

introducing a reversing switch, the c
when required, and the motor can be
braking, the motor is sometimes driv
car, and tends to recharge the battery
is not great. The motor should be
protection against wet and dirt.

The Controller and Dri

The power of the motor may be reg
An adjustable resistance may be intr
or, if the motor be series wound, t
through either the whole or through on
ings of the magnets, thus varying th
tem offers facilities for comparativel
speeds. Another way of regulating th
of parallel and series coupling of the c
cell is usually coupled to its neighbor
tery is arranged in four groups, wit
group, then the voltage of each grou
changes may be rung on the four gro

All four in parallel (all the four ne
one terminal, and all the four positi
other terminal), twenty volts.

Two pairs, each in series, and the

group No. 1 and the positive pole of group No. 4 to be coupled to the two terminals respectively), eighty volts.

It will be observed that the proportions of speed between the parallel, series parallel, and series couplings are as 1, 2, 4, which are rather course gradations.

The instrument for regulating the power of a motor is called a controller. It is provided with a handle, the movement of which to different positions effects the changes of speed, or rather power, as required. At starting, the current is switched on and the controller turned to the first speed position, when the car moves off at a slow pace. When under way, the handle may be turned to the higher speeds in turn, and so on.

The actual driving gear of an electric car is very simple. If only one motor is employed, a pinion may be mounted on the armature shaft and gear with a large wheel on the balance-geared live axle. Or the necessary speed between the armature and the live axle may be made in two steps instead of in one. If two motors are used, the armature pinions may be made to gear with large toothed wheels secured directly to the two driving road wheels; no balance gear is necessary in this case, as the motors adapt themselves automatically to the different degrees of motion required by the two driving wheels in making curves. This feature enables the front wheels to be driven if desired, but the rear wheels are nearly always chosen as the drivers. There is an incidental advantage in the use of two motors, in that should one fail it may be possible to get home on the other.

CHAPTER XIX.

STEAM CARS.

There are several types of steam cars on the market. The earliest successful pleasure steam car was the Locomobile, which is now obsolete. Up-to-date steam car design is exemplified in the White, Gardner-Serpollet, Turner-Miesse, and others. In the steam car the trouble of variable speed gears is done away with, the elasticity of the steam engine being sufficient to allow the car being driven at all speeds with practically equal efficiency.

In the White steam car a vertical double-cylindered steam engine is placed in front of the chassis, in the same position as that occupied by the usual internal combustion engine. The engine is double-acting and compound; that is to say, the steam enters the high pressure cylinder, driving the piston from both ends, and exhausting to the low pressure cylinder, which is of twice the diameter. The exhaust from the low pressure cylinder is carried through a large radiator in front, which in this case is known as a condenser, the steam being condensed into water in this radiator, exactly in the same way as the water temperature is reduced in the radiator of a gasolene car. The drive from the engine to the road wheels is by means of a rear axle of exactly the same type as is used in a gasolene car. There is no change speed gear and no clutch, and the speed is practically governed by the throttle, the amount of steam let into the high pressure cylinder *determining* the speed. In starting the car on an incline, or where a very heavy grade has to be negotiated, the valve between the low and high pressure cylinders can be shut and the steam admitted into the low pressure cylinder at high pressure. In this case the engine is practically a double-cylindered high pressure engine, but will naturally use steam at a very fast rate, and if run for long coupled up in this way it will be found difficult to condense all the steam back. The water is carried in front of the dashboard in a large tank, and is supplied to the boiler by a steam-driven pump. The regulation of the water supply is automatic. The boiler is fired by means of a gasolene burner, the gasolene being supplied under pressure.

The boiler—or more properly the generator—consists of helical coils of steel tubing placed one above the other, and surrounded by a casing of insulated material. The water comes in and is at all times in the top of the coils, while the steam is in the lower coils, and goes out by the coils next to the fire, being thus efficiently superheated. There is practically no boiling water to generate steam, the water being turned into steam as it circulates through the coils. There is an automatic valve, which regulates the fuel supply in exact proportion to the water admitted to the boiler. This is regulated by the engine, so that however much steam the engine is taking, the heat and the amount of water admitted will be just in the right proportion to supply constant pressure of steam. The generator or boiler is placed immediately in the middle of the chassis of the car and directly under the front seats.

In the case of the White steam car no reverse gear is necessary in the usual meaning of the term, the valve motion of the engine being so arranged that the engine will reverse itself. An ordinary link-motion reversing gear is used and slide valves. This is impossible in the case of existing types of the internal combustion engine.

Another Successful Type.

Another type of steam car which has proved very success-

tion engines. The valves, too, are
there being a cam-operated tappet val
the exhaust of all cylinders. The d
Serpollet car is by a countershaft wit
chains to the rear wheel, the engine
countershaft direct by means of gearin

Another type is that having three
and mushroom valves, the engine bei
the middle of the car and with the st

The great advantages of the steam
are almost perfect silence in running
duction in vibration, the balance of t
considerably better than that of the
the driving effort on the crank is alm
reason the transmission is particularly
with a double-cylindered engine there
essity for a heavy flywheel.

STEAM CAR HINTS AND TIPS.

Points of Steam Car Driving.

In using a steam car having a boiler, it is most important to see that a proper level of water is maintained, and this cannot be secured if the tank is allowed to get empty. Therefore, in strange country, keep on the safe side, and fill up as opportunity offers. Even when such a car is standing with only the pilot light burning, it is necessary to watch the gauge glass. And it is also important to see that the pilot light does not get extinguished on these occasions, otherwise when the driver lights up again he may set fire to fuel that has escaped, the car, and anything else within range. Failure of water means certain burning of the boiler, and possibly explosion. If you find you have let it get lower than you ought, do not get flurried, but pump the water in gradually until you have brought it up to the proper level, and—be more careful in future. Soft water should be used to prevent furring; and as a partial cure for the same trouble, at the end of each run the steam should be allowed to fall to about 50 pounds, and then the boiler should be "blown down" with it. The gauge glass should be similarly cleared several times in a day's run.

These precautions do not all apply to a generator such as the White; but whatever the boiler or generator is like, do not fail to empty it and all pipes in frosty weather.

Another cardinal maxim for steam car users is, lubricate freely. Under favorable conditions there is no object in running the slide valve its full stroke; one may notch up to a considerable extent without materially reducing the speed, the expansiveness of the steam being more fully availed of while the expenditure of fuel and water is reduced. Be sure to keep the boiler well supplied with water while climbing hills, using the hand pump if necessary. In starting a White or driving it up a long hill, turn the steam direct into the low-pressure cylinder as well as into the high-pressure, But the marked differences in steam car construction make it difficult to give satisfactory general directions. The instructions given by the makers should be carefully mastered and followed in every case.

Some of the following paragraphs apply only to steam cars of early design—many of which, however, are still in use. Some of the difficulties referred to are obviated in the most modern steam cars.

The Engine Bearings.

The main bearings of the engine and the connecting-rod ends should be examined occasionally. In the White engine the eccentric straps and sheaves have balls between them, which reduce wear and so maintain the accuracy of the valve-setting—a very important item. When replacing a defective ball, it is better to replace the remaining ones in the bearing if there is any doubt about their not being exactly the same size as the new one.

Lubrication.

The engine in steam cars may easily be ruined through defective cylinder lubrication. Mechanical and automatic feeding of the oil is almost a "sine qua non," especially with superheated steam. Condensation lubricators are uncertain in action, frequently flooding the cylinders with oil and then leaving them dry, and a few miles of dry running with hot steam may score the cylinder walls badly.

The mechanical feed usually fitted is very efficient, but if the oil well is allowed to get empty, an oil lock often takes place in the pipe leading to the steam chest, and the pump refuses to work after refilling. The remedy is to disconnect the pipe from the steam chest, where there is usually a coned joint, and work the pump plunger up and down by hand until oil drips through freely, and then to replace the pipe—a matter of a few minutes.

While on the subject of oiling, it may be mentioned that it is a good tip to keep a small supply of cylinder oil in a can hung up close to the engine or boiler, and to replenish the oil well as soon as the car comes in, so as to avoid the troublesome delay in pouring out heavy oil when cold; this applies especially in winter. The cylinders will be very freely oiled if the lubricator is about three parts emptied after thirty or forty miles running, when it can be conveniently refilled at the same time as the water tank.

Engines.

None of the earlier steam engines have large enough bearing surfaces; the crossheads especially are inadequate, and wear rapidly. As soon as there is any play between the crossheads and slides trouble is likely to occur. The cylinders in time will wear oval, necessitating reboring and new pistons and rings. The rear slides will show more wear than the front ones, since all the pressure of the crossheads is against the former in forward running. Compensation is effected when the wear is slight by packing up the slides with thin hard paper, but the parts will probably need scraping true, as the wear is not even, being most pronounced at the top and bottom opposite ends. It may happen with ball-bearing connecting rod ends that tightening the adjusting cone fails to cure any "shake" there may be, and if the cones are otherwise good it is possible to grind down the face of the cone on an emery wheel, so that it screws up farther and drives the balls out against the race. If they are softened for the purpose of being worked in a lathe and rehardened, they may warp and not screw on again nicely.

Superheating Steam.

This is one of the greatest improvements in light steam cars, but is apt to cause trouble in some of the engines constructed for wet steam. The Weston type of superheater, which is fixed between the boiler and throttle valve, is far better than one between the latter and the engine, the temperature being less extreme, and the throttle controls the car better, even with this. Some have found, however, the heat sufficient to melt the solder in the joints of the feed water heater, causing the original packing in the cylinder heads and valve chest cover to leak. It is said that soft copper is better, and this would save the renewal of the other material, which, of course, involves pulling the engine to pieces and a great amount of time and labor. The engine glands need more attention with dry steam. Care should be taken that the springs which prevent the collars from unscrewing are really effective, as they sometimes get bent away when the tightening up is done with a screwdriver, and being in a very inaccessible position this may not be noticed. When once well packed and screwed up, the glands should only need a few threads of asbestos added from time to time. Sometimes special packing washers are supplied. The addition of graphite to the asbestos is an improvement.

All glands and joints should be kept under observation, as a little water continually lost, or a little steam leaking, may cause some surprise as to the capacity of fuel and water tanks. Leaking joints have long been among the handicaps of steam cars, and it seems a pity that ground unions are not used more in parts which are likely to be taken apart, as they require no packing, and their attachment to the pipe can be a permanent joint screwed up very tight. Pipes should everywhere be as springy and flexible as possible.

Boilers.

The fire tube boiler in conjunction with a superheater has some points in its favor in comparison with a flash generator, especially in regard to the length of life, which, however, is greatly dependent on the care with which it is treated.

The water gauge in the form usually seen is troublesome to watch, and, owing to the smallness of the pipe leading to it, is very apt to get choked and give a false reading. If the water does not rise briskly in the glass when the gauge is "blown off," the driver had better beware of a burnt boiler. Sometimes blowing off fails to clear the pipes for some time, and it is then better to risk flooding the boiler than burning it; the pipes frequently clear themselves after a journey of some miles when more or less choked at the start. There are, however, forms of gauge that are very easily read, especially at night.

The fire tube boiler is not very workable with return water arrangements, unless there is a perfect system of oil filtration, for a small quantity of oil in the boiler will do harm, but is of no consequence in the flash tube form. Blowing out the boiler constantly and the use of water that does not leave deposit are the best means of keeping it in good condition. This is one of the difficulties in touring, and the flash boiler is not affected in the same way, no deposit being left in the tubes. Water is conveniently taken into the tank with a small injector, and the end of the hose is usually provided with a fine strainer, which prevents any foreign matter getting into the tank.

Burners.

If the burner has a vaporizing tube passing through the fire, or kept hot with a pilot burner, it is quite easy to use heavy fuel oil. There is not much difference in working between this and the more expensive quality of spirits, except that the vaporizer requires cleaning more often, and also, of course, the bypass. These were so unhappily arranged in some early cars as to necessitate removing the fire-box and unscrewing several joints, which could easily be avoided by a more intelligent scheming of the connections, and, as a matter of fact, is avoided in all steam cars that have survived at the present time.

If there is iron wire in the vaporizer, it should not be packed so closely when inferior spirit is to be used. A superheater diminishes the necessity for a large "fire," as there is usually plenty of steam with the fuel valve very slightly open, and there is no need for a higher pressure than 30 lbs. in the tank. Some find 10 lbs. sufficient if the vaporizer is clean. A steam air pump in consequence is not a very important accessory, although useful on a long journey when the tank is full of spirit at the start. In its absence, it is necessary to pump the air pressure to about 60 lbs., which pressure rapidly falls in the first ten miles, and if there is a separate bypass burner, it will need turning on a little more to compensate for the drop in pressure, or it may go right out. We are assuming that the driver starts with a high pressure to avoid pumping up on the way, but if there is a steam or mechanical air pump he need not do this, but can set it going at any time for a few minutes, and keep the air gauge at an even pressure.

The Effect on the Bodywork.

The coachwork of a steam car is more likely to get spoilt than that of a gasolene car. The heat from the flue and escaping steam are injurious to a highly finished body. The boiler, therefore, should not be blown off in the usual way, a much better method being to have a few yards of rubber tubing to screw on the boiler connection, and thus lead the escaping steam and water away from the car. The end may conveniently be put into a drain or the open end of a pipe.

The absence of dust-raising properties in light steam cars is a great point in their favor; very little is noticeable when traveling fast as compared with gasolene cars with bodies nearer the ground.

Economical running is best attained by working at a fairly high pressure and cutting off with the reversing handle whenever the road conditions and traffic permit.

Water Gauge Valves.

If users of steam cars ever notice their water gauge at a standstill while under steam, they should without delay try the lower check valve to see that it has not become seated. These check valves have above them a small handwheel, the screwing down of which releases the valve. It is possible for this to happen and the boiler tubes to get burnt as a consequence.

Care of Crosshead Guides.

Take particular care to see that the crosshead guides of a steam car engine are plentifully supplied with oil, and that undue wear does not take place. These guides have to take the angular thrust from the connecting rod, and if they become much worn there is a danger of the piston rod bending in an extreme case. However little the wear may be on the guides, the bending movement distorts the packing in the stuffing box, causing it to leak. Constant repacking will keep the cylinder steam tight at the stuffing box, but the real cause of the trouble lies in the bending of the connecting rod.

Fitting New Gauge Glass.

To put in a new water gauge glass of the ordinary steam engine type, first remove the broken glass and take off the packing nuts. The indiarubber rings which form the water-tight joint must be removed and, if damaged, replaced. The packing nuts should be put on the new glass, open ends outward, and the packing rings slipped on to the ends of the glass, which should then be placed in position. Screw up the packing nuts carefully. The automatic check valves will be down on their seats, and must be released. To do this, screw down the small handwheel above each valve three or four complete turns, which will release the valve. Unscrew the handwheel to its original position. If the gauge glass is put in while the boiler is under steam, release the lower check valve first to admit water. Steam is liable to crack a new glass.

Straining the Water.

Always strain the water as it is put into the tanks of a steam car; failure to do this sometimes results in a feed pump becoming choked and failing to act.

Blow Off After Fifty Miles.

Blow off fire tube boilers after running about fifty miles. It prevents the formation of scale, and so keeps the steaming

gives the slide valves a short travel,
cut-off, which enables the best results tc
expansive qualities of the steam. For l
requires its greatest travel, to delivei
steam to the cylinder.

Start a Steam Car Sl

Always start a steam car slowly, ar
first few minutes. Water always remai
and in the engine itself, from the coı
previous run. This water must be go
cylinders, etc., warmed up before the
doing its full amount of work.

Starting Up Steam Gen

When starting up steam generators
have the vaporizer well heated. Slow f
are the result of insufficient heating.

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